When the chemistry is right:
A study of work organization and change in two chemical plants

by

Peter Bernard Cebon

Bachelor of Engineering, University of Melbourne, 1984
Master of Science, Massachusetts Institute of Technology, 1990

Submitted to the Sloan School of Management
in Partial Fulfillment of the Requirements for the Degree of:

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Abstract

This dissertation compares the management and performance of two matched chemical  
plants, with different work organizations, and asks two straightforward questions. First, what  
are the similarities and differences in work organization, and how do these explain differences  
in productivity and safety performance? Second, what is the process by which change is  
occurring, or not occurring, in the two plants?

The first third of the dissertation describes the technology and activities associated  
with “compound” production, and shows how technology, when considered alongside  
similarities and differences in history, the institutional environment, and management  
strategy, can lead to the differences in work organization in the two plants. These differences  
are then described in detail.

The second third addresses the first research question. I argue that the differences in  
organizational performance are best understood in terms of three clusters of variables: skills,  
stance, and flexibility. Skills refer to peoples’ abilities to perform their technical tasks and to  
work together. I found both to be higher at team-based Wideplant. Stance is the way people  
stood in relation to each other. I constructed it by aggregating the traditional variables of  
power differentials, trust relations, and the desire to control each other. I found that stance  
differences led to differences in peoples’ behavior in domains such as their discipline in  
completing routine tasks, their willingness to enact and deal with the problems they saw, their  
tendency to misattribute motives to others and therefore perform the wrong task, their tendency  
to impose their will on others capriciously, their desire to help each other, and their tendency  
to suppress information and learning opportunities. I also found that differences in stance led to  
differences in the modes of rationality expressed in the plants. In particular, rationality at  
Highplant tended to be more formalized, rule-based, and power driven, while that at  
Wideplant tended to be more practical, or principle-based. Excesses of either can cause  
problems within the organization. Flexibility is the capacity to cope effectively with  
variations in the institutional environment or the strategies of actors. I argue that it is created  
by having either multiple routines available for the completion of a given task, or multiple  
and overlapping resource pools to draw from when solving problems. I illustrate the way  
differences in flexibility lead to differences in outcomes in the plants.

The final third of the dissertation addresses the second research question. After  
recounting the histories of change in the two plants, I describe change’s political and cognitive  
dimensions. I then describe the two major change approaches I observed: selection, or replacing
the people you have with the people you want, and adaptation, or helping the people you have to become the people you want. Within the adaptation approach, I identified three strategies: teaching people the new organization, proactively restructuring the organization so people will have different experiences, and strategically exploiting sense-making opportunities. When the selection and adaptation approaches were applied simultaneously, a third set of approaches emerged. Of particular importance in this category was the use of selection to provide prototypes on which people who were trying to adapt could model themselves. After a discussion of the barriers to change I observed, the dissertation elaborates on the third adaptation strategy -- strategic sense-making -- by analyzing the investigations of four accidents, and their ramifications for the organizations.

The analysis is carried out by examining the organizations' processes. In particular, I focus on differences in the ten different classes of tasks I observed along three dimensions. Some tasks were routine while others were exceptional. Some tasks were production-focused, while others were learning-focused. Finally, within the exceptional tasks, there were four types of activities: initiation, sense-making, problem solving, and implementation, while the routine tasks had just an implementation stage.

In order to answer the research questions, the dissertation addresses a number of questions central to organization theory. In particular, it considers the relationship between technology and structure, the nature of flexibility, the relationship between politics and cognition and its impact on learning, and causation processes for accidents.

Thesis supervisor: Dr. John S. Carroll

Title: Professor of Management
Acknowledgments

Sitting here, writing the last few words of what has taken too many years, it is humbling to think of the number of people who have taken time to help me do what I wanted to.

First and foremost, I would like to thank the Transitech employees who not only gave up a huge portion of their time, but took a tremendous personal risk to participate in the study. As in many large corporations, for some (but certainly not all) employees, Transitech is not a secure place. Many people felt vulnerable to having what they said and did examined. They didn't fear what I might say, but rather, for what others in the corporation would do with what I said. Some of the people at Wideplant felt their jobs depended on their being better than Highplant, and worried that I would make it too easy for Highplant to learn. Some people at Highplant feared that things they said would be used against them, either individually or collectively by their coworkers, or supervisors. In return for my simple promise of anonymity and untraceability of the people, the plants, and the corporation, they chose to participate. I hope I've managed to keep my side of the bargain. At each of the plants, there were five or six operators, mechanics, engineers, supervisors, or members of plant leadership who were tremendously supportive and helpful. Unfortunately, I cannot name them. In addition, my sponsor's secretary was a constant source of logistical support and cheery conversation.

The Transitech oversight committee included the senior people who gave me access to the various groups, the overall project sponsor, and other people who were brought in from time to time. I have decided that this dissertation is so long and complex that anyone who reads it from cover to cover could only do so out of love, institutional responsibility, or stupidity. In addition to seeing enough virtue in the project to allow their organizations to be studied, this group read the whole thing twice. I assume that institutional responsibility drove them to it! Their first reading proved invaluable to the final product. First, they provided tremendous quality control by showing new ways of seeing and understanding the data and pointing out my errors. While, by no means, did I change my writing to represent their views, they certainly showed me things I hadn't seen before. This enriched the analysis considerably. More important however, when the story is long and complicated, it is very easy to forget to say why you wrote things and to leave the analysis too far below the surface. Their insistent challenging of many points was instrumental in my decision to completely reorganize the material after MIT had said the draft was acceptable. Within that group, the project sponsor must be singled out for special thanks. Not only did he have the vision to see the potential in a project, but he provided some financial support, traded some political favors to get me access to one of the sites, provided tremendous mentoring throughout the difficult stages, was always a friend, and managed throughout to maintain a stance which was completely neutral to my findings.

My intellectual debts are many. First and foremost, I must thank John Carroll, who jumped into the breach to supervise the project when Tom Kochan became too busy. He did a fantastic job, and made me regret that I didn't start working closely with him much earlier. Only through many hours of conversation did we manage to sort out the material on attribution error and separate it from the material on formal rationality. In addition, he provided detailed feedback on several drafts of each chapter before the first "final" draft was completed, the entire first "final" draft, and the entire second "final" draft. I doubt his wife
Helene will ever talk to me again. I have enjoyed virtually every conversation and am grateful for having had the opportunity. In addition, I would like to thank Tom and the other two members of the dissertation committee, John Van Maanen and Maureen Scully. I put together an eclectic committee because I was convinced that each of their areas of expertise would add to the content of the dissertation and each of their working styles would force me to deal with my own weaknesses. I was right on both counts.

A number of other people either provided specific advice or a welcome ear as I tried to sort through the ideas. The ideas on flexibility were helped considerably by a series of conversations with Michael Piore. Leon Mann's comment that the transition was very slow opened up an important door, as did Renée Oatway's suggestion that I think about reference groups, Richard Hackman's suggestion that I think about the forms of the various procedures, Brian Pentland's insistence that incidents should be "the" unit of analysis (and a whole lot more), a discussion with Fred Kofman's on the difference between metaphor and simile, and Wendy Guild's assertion that organizations don't make sense (of events), people do. Hugh Gusterson helped me make sense of sense-making in the context of the social construction of science, and Allisa Bernstein taught me the difference between socially constructed knowledge and epistemology. In addition to Brian, there were three people who were always available to talk irrespective of their other commitments or the time of day. Special thanks go to Ted Homer-Dixon, Yiorgos Mylonadis, and Amy Edmondson. Many other people at MIT and Harvard also contributed less directly to the study. While I would like to name half the faculty and most of the students individually, I’ll restrict myself to Bob Thomas, Lotte Bailyn, Jim Rebitzer, Richard Locke, David Guston, Elaine Yakura, and Anjali Sastry.

Dissertations are not cheap, and this one was no exception. In addition to the support from Transitech, I received considerable help from John Sterman, Peter Senge, and Ed Schein at the MIT Organizational Learning Center (in addition to their intellectual input), Bill Clark, Bob Frosch and Lew Branscomb at Harvard, and Carlo Jaeger here at EAWAG, who indulged my desire to rework the text. In addition, Oscar Hauptman did me a huge favor, about which I must be vague for confidentiality reasons, and David Rabkin facilitated the miracle of thesis printing via satellite.

Finally, there are the people whose love and support often meant the difference between going forward and giving up. Virtually everyone above provided more than their fair share, as well as a number of other people whom I haven't mentioned individually. However, I would like to single out Yiorgos Mylonadis (despite an off-the-cuff comment which initiated the study and added two years to my stay at MIT), Brian Pentland and Tad and Jill Homer-Dixon from the list above. In addition, at key times, Jill and John Conway, Kate Baker-Carr, Peter Poole, Arianna Jarvis, James Risbey, and Terry Hill (who also edited the entire manuscript) made (and will always make) all the difference.
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1. Introduction

This dissertation examines the organization and management of two chemical plants -- Highplant and Wideplant -- owned by Transitech. The two plants manufactured the same product, and were similarly organized in the early 1970's. However, by the early 1990's, the organizations were quite different, with Wideplant operating with self-managed teams. The similarities and differences are introduced in more detail in an appendix to this chapter. The dissertation asks two questions. First, what are the similarities and differences in work organization at Highplant and Wideplant, and how do these in turn explain differences in their productivity and safety performance? Second, what is the process by which change is occurring, or not occurring, in the two plants?

Research questions

The research questions which motivated the data collection were very straightforward. First, despite the huge amount that has been written about the "new organizations", we know surprisingly little about the way they work. Most of the empirical work has been done in the automobile industry, which is technologically quite different from other forms of manufacturing (e.g. Woodward 1965; Goodman 1990). In particular, as we will see below, a chemical plant is organizationally much more complex than an automobile plant and operates on a dramatically different time scale (days, rather than minutes). It is a major achievement to simply get the thing up and running smoothly. Furthermore, notwithstanding claims by authors such as Perrow (1984) that it is impossible to manage a high-hazard technological organization safely without strict hierarchy on one hand and simultaneous flexibility on the other, both commercial and institutional pressures are leading the chemical industry to eliminate hierarchy and experiment with new approaches to manufacturing. While the management of this paradox of simultaneous flexibility and structure been examined for aircraft carriers (Roberts 1993), very little work has been done in lightly regulated commercial organizations. Finally, once I started gathering data, it became clear that Wideplant, while clearly high performing, was not performing well for the reasons which are usually given in the literature, or even for the reasons management claimed. For example, there were no employment guarantees, people weren't particularly in love with the new organization (though no one wanted to go back to the old) so we can't assume they were all motivated, and there was limited evidence that the particular cognitive transformations management was looking for were really present. Given all the above, I felt that my first task (which takes up about 75% of the text) was to simply lay out and explain the differences between the organizations, and the way those differences led to different safety and production outcomes.

Second, with over 800 books on organizational change in the MIT libraries, it would be rash to make any generalization: whatsoever, (except maybe to say that organizational change is either difficult or lucrative). Notwithstanding, there are two dominant strategies for putting these new forms of work organization in place. One is to build "greenfield" sites, and the other is to sack workers and hire them back again, creating a quasi-greenfield site. In the chemical industry, where it takes workers about 10 years to develop a full set of skills, and where a plant has a life of about 30-40 years (and where the infrastructure is very tightly constraining), greenfield sites are only an option for expansion, and "sack and hire back" is a
very expensive alternative. Therefore, plant owners are forced to attempt a change process. As
in most industries, most attempts at change in existing organizations have been failures.

This suggests that three aspects of the change process are problematic. First, we have
the "miracle of Wideplant", a supposedly successful transformation case, that no one else seems
to have accomplished. This needs to be explained. Second, as Leon Mann noted in a discussion
of this work once, "15 years is a long time to put teams in place". The slowness of change needs
to be explained. Third, these are very dangerous plants. They can fail in infinite numbers of
ways, and with horrible effect. Even the simplest systems model would suggest that their risk
of dramatic failure during an organizational transition is much higher than in the steady state.
The maintenance of safety during the transition is problematic and needs to be accounted for.
Therefore, the second research question was simply to ask how the change had occurred.
Highplant provides an excellent contrast in this regard in that it was also attempting two
change efforts during the study - one toward the transformed work organization and one
toward greater safety performance.

Theoretical framing

This study uses theory on two levels. At the first, I use a grounded-theory approach to
construct a framework to answer the research questions above. That framework is laid out in
the next section. At the second, the results of this study engage a number of contemporary
debates in organizational theory. In general, I do not bring those debates to the surface
explicitly. Rather than using the data to illuminate theory, as is the usual case, I decided to
only present as much theory as was necessary to illuminate the data and answer the questions
above. Notwithstanding, these other questions, and their origins, are discussed briefly here.

The research questions lead directly into a question about the relationship between
technology and organization. I address this in two ways. First, in chapter four, I examine the
way people perceive time and relate that to different activities in the plants. Second,
throughout the dissertation, I recast the different activities in terms of organizational
coupling, by applying it to the relationship between organizational elements, rather than at
the system level where it which is usually used (e.g. Weick 1976; Meyer and Rowan 1977;
Perrow 1984). Both approaches enable me to then tie the data into the literature on technology
and organization. In particular, I will reconcile a disagreement in the literature between those
who argue that organizational structures are driven, essentially, by the routine aspects of the
work (e.g. Mintzberg 1973; Nelson and Winter 1982; Williamson 1986; Goodman 1990), those
who emphasize the management of exceptions (e.g. Woodward 1965; Lawrence and Lorsch 1967;
Perrow 1967; Thompson 1967; Hickson 1971), and those who claim the relationship between
technology and organization is, at least in part, negotiated (Barley 1986; Barley 1990;
Orlikowski 1988).

Second, I went into the field with two theoretical questions in mind, coming directly out
of my general examinations, my prior work, research affiliations at MIT, and the original
question for this study. First, I wanted to understand what it meant for organizational learning
to occur in a politicized environment. It seemed that all of the literature on learning assumed
that the workplace was free of politics. However, my earlier work on energy and
environmental management, plus Bob Thomas's influence (Thomas 1994) suggested that politics
must be an important part of the story. Furthermore, my reading, the MIT culture-in-
organizations-aura, and the work of my friends all suggested that politics alone would have
low explanatory power. Somehow the two would need to be integrated to tell an intelligent
story. It appears this hunch was correct. The interaction between politics and cognition, as
both attribution errors and formal rationality was much more important than either effect alone, both as a predictor of performance, and of capacity to change.

Third, I had spent a couple of years thinking about what it might mean for an organization to be flexible, and what the relationship might be between flexibility and learning in organizations (Cebon 1991). I developed these ideas further in my research work at FLECSOCO, and developed the precursors of the model presented as chapter 12. I wanted to know if this model made sense. I found, as I collected the data, numerous examples of this kind of flexibility influencing outcomes in an important way. However, I discovered only at the very end of the study that it was vital for explaining the differences in performance (the particular example has to do with maintenance scheduling, though it is an answer to a more general problem of achieving high performance in a context where there is low consensus -- as in a transition -- and low slack).

A fourth set of theoretical questions arose out of the analysis. In particular, as I tried to make sense of the accidents which I analyze in chapter 17, it became obvious that Perrow’s Normal Accidents theory (Perrow 1984) was inadequate. It seemed that every accident I could imagine met his criteria. This led to a very fruitful exploration into the meaning of tight and loose coupling, the nature of causation, their relationship to sense-making and its relationship to culture, and (indirectly) the nature of the process by which we, as scientists, create analytic constructs.

Some definitions and the underlying conceptual framework

The analysis is carried out by comparing the process by which the organizations managed matched sets of activities in the plants. The activities are of twelve types, categorized according to the framework described below. The framework is both emergent from the data and consistent with the existing literature. That is, I have derived it, in large measure, out of the data. However, some of the elements (particularly the use of social cognition theory), and many of the terms, are drawn from the literature. Even there, however, the relevance of that particular literature only became apparent during the analysis. I will not discuss the way the constructs emerged from the data here, since the reader will have the opportunity to see that in the body of the dissertation. I will simply introduce the terms here, with the minimum amount of relevant theory from the literature, and describe the relationships among them.

Action is purposive

The starting assumption is that action is purposive. That is, people in an organization choose to act. The aim of the dissertation is to show the way in which the organization structures that action, and the way that action shapes organizational outcomes and the organization. Therefore, every action has two phases. The first phase is the initiation, and the second phase is the execution. This is presented in table 1.1.

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Initiation</th>
</tr>
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<tbody>
<tr>
<td>Phase 2</td>
<td>Execution</td>
</tr>
</tbody>
</table>

Table 1.1. Phases of any purposive action

15
Initiation of actions

I observed that choices occurred in a number of different ways. These are summarized in table 1.2.

<table>
<thead>
<tr>
<th>Initiation method 1</th>
<th>Deciding individually to act</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation method 2</td>
<td>Deciding collectively to act</td>
</tr>
<tr>
<td>Initiation method 3</td>
<td>Asking someone else to act</td>
</tr>
<tr>
<td>Initiation method 4</td>
<td>Acting when asked</td>
</tr>
</tbody>
</table>

**Table 1.2. Ways in which actions can be initiated**

Execution of actions

Knowing what to do

To act purposively, a person has to know what they are doing. Social cognition theorists in psychology (e.g. Rosch 1978), linguistics (e.g. Lakoff and Johnson 1980; Lakoff 1987), and anthropology (e.g. Holland and Quinn 1987) have developed a persuasive theory which describes what it means to "know", and I will use that framework throughout this dissertation, modified, as we will see in chapter 14, to account for the fact that people don't hold organizational truths as deeply as those about the outside world.¹

Holland & Quinn (1987) in the introduction to their very influential book, describe the cognitive anthropologists' approach to the social construction of knowledge by building from an argument that was pioneered by Lakoff (Lakoff and Johnson 1980; Lakoff 1987). They claim that cultural models of knowledge can be understood in terms of two types of schemas: 'image schemas' and 'proposition schemas', and two types of relationships within and between schemas: metaphor and metonymy. While Lakoff's (1987) version of this theory claims people understand the world through idealized cognitive model's (ICM's), Quinn and Holland's is a little more open. However, both models are built from the same four elements: propositional models (proposition schemas) and image-schematic models (image schemas), metaphors and metonymy. While I will bring in more of the theory later, we will focus on the relationship between proposition schemas, image schemas, and organizational action in this chapter.

The relevant central idea in the theory is that people understand the world as a network of proposition schemas linking image schemas. We will represent it as in figure 1.4:

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¹ The social cognition approach has limitations. In particular, it presents the organization as if all the people are schematic representations of their real selves. All readers who are proud owners of a soul or emotions should accept my apologies.
For example, a very widely held belief in Transitec (and virtually all organizations) is that “management of the organization leads to organizational outcomes”. This belief is represented in figure 1.5.

Types of actions

I observed that any action in the organizations (including initiation) had one or more of the following three components, which I will call activities:

| Activity 1 | Sense making |
| Activity 2 | Problem solving |
| Activity 3 | Implementation |

Table 1.3. Activities within an action

Consider a person who is faced with an unexpected problem. First, they may try to understand what the problem is that they are trying to solve. This is sense-making. For example, I might observe that I have pain in my stomach. I think about this pain for a moment and realize that I am hungry. Once they know what the problem is, they might develop a solution to the problem. This is problem solving. I walk downstairs, and check the contents of the cupboard and the refrigerator. Pretty disgusted, I look in my wallet and realize I am still a graduate student. I decide that there is a dinner that I can scratch together from the food I have already. Finally, they will go and implement the solution. I cook myself a mouthwatering dinner of leftovers and dubious limp vegetables.²

² While, for my hunger, sense making preceded problem solving, which in turn, preceded implementation, that is not always so. In particular, in loosely coupled organizations (Cohen, March et al. 1972), or organizations with a lot of slack (March and Simon 1958), problem solving often occurs, and then the advocates of those solutions find situations in which their solution addresses the problem they find or create through sense-making.
We can represent these three activities schematically. In the case of sense-making, we know the outcome, but we don’t know what caused it. The task of sense-making is to work out what the cause is.

![Diagram](image)

**Figure 1.6 The situation before sense making**

Through sense making we hypothesize the causal process which led to the current (undesirable) state of affairs.

![Diagram](image)

**Figure 1.7 The situation after sense making**

Given an alleged cause, we design a "solution". That is, we design an intervention which will act on the cause of the current state of affairs to convert that state of affairs into a more desirable one.

![Diagram](image)
Figure 1.8 The situation before problem solving

At the start of problem solving, we have an alleged cause, and we have a desired end state which we hypothesize will make the alleged cause better. The task is to design a process which will take us from one state to the other.

Empty stomach  →  Cook dinner  →  Full stomach = lack of pain

Figure 1.9 The situation after problem solving

In the case of implementation, we know the current situation, and we know what we are going to do about it, but we don't know whether it works.

Current state  →  Proposed action  →  ?

Empty stomach  →  Cook dinner  →  ?

Figure 1.10 The situation before implementation
That is, only after implementation do we know whether the intervention will achieve the desired state, or whether the desired state will successfully negate the current state. Implementation enables us to test our sense making and our problem solving.\(^3\)

![Diagram: Empty stomach → Cook dinner → Food poisoning = emptier stomach and more pain]

**Figure 1.11 The situation after implementation**

These three processes -- sense making, problem solving, and implementation -- are recursive. In the case of my hunger, I am lucky. Because it is hard wired into my body, I have known the relationship between that pain in my stomach and hunger since birth. For virtually all other activities, however, we have to work out how to work out what the stimulus means. That is, the act of sense making contains three components: sense making, problem solving, and implementation. First we work out what it means to work out what the problem is. Then we work out how we are going to go about it. Finally, we implement our solution.

For example, consider the problem of "incident investigations". Incident investigations are a process which the plants studied here carried out to work out why certain untoward events occurred. That is, they were a formal sense-making exercise. However, if you think about it for a minute, you realize that before the organizations could work out why an untoward event occurred, they needed to know two things. First, they needed to know what events were untoward events. Second, they needed to know how to go about working out how the untoward event occurred. These two realizations are, of course, the results of a sense-making exercise. If they actually worked out how to conduct an investigation, or how to work out if a disturbance is an untoward event, then they would have been problem solving. After they had solved the problems, they could go back up a level and implement. However, once they started to do these, they would find, again, more sense making, problem solving, or implementation activities. The same is the case for problem solving and implementation activities.

**Routinization**

In order to prevent paralysis by infinite regress, organizations routinize some of these activities.\(^4\) That is, they codify the process by which the activity is carried out. Routinization can occur through the writing of procedures. It also occurs, however through the use of learned norms and by training. In the case of the incidents, the plants both had

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3 As we will see several times throughout this dissertation, the capacity to carry out that test depends on a relatively high frequency of events that allow a test to be carried out. However, many of the events of interest (e.g. accidents of a similar type to the one under consideration) have very low frequencies.

4 In addition to the use of routinization, people working alone also use metaphor and metonymy, to prevent infinite regress. This is particularly the case in novel situations (see Lakoff, 1987). In organizations, direct use of power to tell people what to do is also a substitute.
procedures that told people how to work out if an event was an incident, and procedures for conducting an incident investigation. In addition, they also had norms for interpreting which parts of the procedures were important and which could be essentially ignored.

Types of tasks

The final typology I will lay out in this framework is the types of tasks people performed. These are arrayed on two dimensions. On the first dimension is the level of predictability of the tasks, that is, the dynamics of their execution. I have called predictable tasks routine and unpredictable tasks event management tasks. On the other dimension, the tasks are arrayed in terms of their content. I have described three types. Those related to the production process (very broadly defined) are called production tasks, while those separate from production, but concerned with it are called learning tasks. In addition, I have added a third task type called management tasks.

Arranging tasks by predictability

While these different tasks have a common-sense feel to them, it is possible to define them more rigorously in terms of their relationship to time, the three types of activities above (sense-making, problem solving, and implementation), and routinization.

Routine tasks differ from event management tasks by their lack of "surprise". For routine operations, all three activities -- sense-making, problem solving, and implementation -- have been routinized. This means that, at all points of time during the activity, the people involved all know exactly what to do next and what sorts of outcomes to expect from their actions. It does not mean, however, that they know what the eventual outcome of the whole stream of activities will be. For example, if a panel operator is sitting in a control room, and an alarm goes off, the alarm indicates that the process has deviated in some way from normal operations. I will define such a deviation as an exception (after Perrow (1967)). However, if you asked him, the panel operator would not consider an alarm going off to be a surprising event. Instead, he would silence the alarm, look on the panel (or the VDT screen) and make a diagnosis. If he "knew" what was going on, he would take some corrective action, either adjusting the process, or contacting an operator in the field. If he knew what to ask of the field operator, and the operator knew what to do in response, it would still be routine, even though the panel operator didn't know exactly what the problem was (see also, Pentland 1991). It is only when the field operator calls in and says that he can't see anything wrong with the pump that the exception becomes an event.

Surprises have a normative aspect to them. That is, what is called a surprise has a lot to do with what is expected. This is particularly true for behavior. We will see that there were many behaviors that Wideplant personnel could exhibit happily toward their supervision which would have been totally unacceptable at Highplant, and a source of considerable "surprise". The converse is also true.

There are two other ways in which this exception can become an event in addition to not knowing what is happening. The first is that the operator knows what the problem is, but doesn't know what to do to return the system to normalcy. For example, the pump won't stop, even thought he has pushed the "stop" button. The second is for the operator to know what to
do, but it is no longer possible to return the system to normalcy. For example, the tank has already overflowed.\textsuperscript{5}

<table>
<thead>
<tr>
<th>Dynamic task type 1</th>
<th>Routine tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic task type 2</td>
<td>Event management tasks</td>
</tr>
</tbody>
</table>

Table 1.4 Types of tasks, arrayed by predictability

*Learning tasks and production tasks*

Learning tasks are quite different from production tasks in that learning tasks are temporally (and generally spatially) separate from events which occur. This is not to deny that people learn while they are doing, or reflecting on, production work (e.g. Schön 1987). Of course they do (though even in that case, the generalization of the understanding probably comes later also). The point is that, at both plants, there were a number of activities which were directed specifically at learning. These all had one thing in common: they all occurred at a different time to the relevant events. For example, the morning meeting would happen some time up to 24 hours after an event. Similarly, an incident investigation might happen a week later. Finally, a process hazards review is an attempt to learn about events which could spring from the technology, before they have a chance to occur. Because they were separated temporally from events, learning activities also tended to be separated spatially. That is, they did not happen in the control room, or in the process areas. Instead, they would occur in a quiet room some distance away.

When describing the work of the managers, it is harder to differentiate the production work from the learning work. There are two reasons for this. First, for them, the production process is not spatially constrained in nearly the same way as for the operators. Rather, their production “process” involves the manipulation of abstract symbols. Second, and following directly from this, a lot of their production work involves “learning”. So, for example, if the management group for the plant were to meet on Mondays to discuss the past week, most of the work would be production -- reporting and receiving feedback -- but a good deal of it would also be trying to make sense of what had happened.

Learning tasks, if sufficiently routinized, can be quite routine. Consider, for example, a process hazards review -- an exercise directed at ferreting out potential accidents. Although these aim to produce findings which were previously unknown, the process by which it occurs is completely predictable. Incident investigations and morning meetings can be the same way.

In addition to learning and production tasks, there are probably others. I define a category of "management tasks" in which one person tries to transmit what they already know to the other person. In practice however, this sort of activity tended to occur during learning tasks. For instance, on hearing about performance of a particular function, a manager would utter approval or disapproval of the way the task was performed. Notwithstanding, since only the first two are important for the dissertation, management tasks will not be discussed beyond this point.

\textsuperscript{5} This definition of an event does not come from the data, but was imposed by me. As we will see in chapter 11, I tried to determine how the people in the plants defined exceptional events. Unfortunately, it was not possible to separate people's own beliefs from the plants' routinized definitions with the methodological tools I had available.
<table>
<thead>
<tr>
<th>Task content type 1</th>
<th>Production tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task content type 2</td>
<td>Learning tasks</td>
</tr>
<tr>
<td>Task content type 3</td>
<td>Management tasks</td>
</tr>
</tbody>
</table>

Table 1.5 Types of tasks arrayed by content

<table>
<thead>
<tr>
<th>Phases of an action</th>
<th>Initiation, Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of initiation</td>
<td>Deciding individually, deciding collectively, asking/being asked</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of schemas</th>
<th>Image schemas, proposition schemas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental building block of knowledge</td>
<td>A proposition schema linking two image schemas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of activities</th>
<th>Sense making, problem solving, implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense making</td>
<td>Hypothesizing the initial image and the linking proposition on the basis of the final image</td>
</tr>
<tr>
<td>Problem solving</td>
<td>Designing the process which will link two image schemas</td>
</tr>
<tr>
<td>Implementation</td>
<td>Imposing a designed process on some initial conditions to induce the hypothesized final state.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Routinization</th>
<th>Codification through procedures, norms, or training, of the process by which sense making, problem solving, or implementation occurs.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Routine tasks</th>
<th>Sense making, problem solving and implementation are either completely absent or contain no element of &quot;surprise&quot; if present. Contains some element of &quot;surprise&quot; which makes returning the system to normal problematic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event management tasks</td>
<td>Occur in real time and proximate to production Occur retrospectively or prospectively, and are often spatially removed from production.</td>
</tr>
<tr>
<td>Production tasks</td>
<td>Catch-all for all non-learning, non-production tasks</td>
</tr>
</tbody>
</table>

Table 1.6. Summary of elements of the typology

The typology suggests that there are twelve distinct classes of activities carried out at each site. Routine tasks require initiation and implementation, while exception management tasks require initiation, sense making, problem solving and implementation. These six activities can occur in the context of either production or learning.

Summary of the argument

As noted above, the dissertation compares the management and performance of two matched chemical plants, with different work organizations, and asks two straightforward questions. First, what were the similarities and differences in work organization, and how did these explain differences in productivity and safety performance? Second, what was the process by which change was occurring, or not occurring, in the two plants? The analysis will be conducted by recording similarities and differences in the way people defined and carried out matched pairs of the twelve activities at the two sites, defined in the previous section, and by using observations, conversations, interviews, and documentary materials to explain these
similarities and differences in a coherent way. The dissertation is divided into three parts, with the first part describing the sites, the second explaining the differences in performance, and the third part examining issues around organizational change.

Chapters 3 and 4 describe the technology in the plants and the work that is done to operate the technology respectively while chapters 5 and 6 aim to explain the work organization constructed to operate the technology. While most of this is a relatively straightforward documentation of the technology, the work, the work organization, the institutional environment, and so forth, at least one aspect of the task is problematic. In particular, given a large literature which claims an intimate link between technology and organization, and an extremely tightly coupled process (the mere presence of the day staff was enough to make it run badly), the existence of two dramatically different organizational forms needs to be explained. Therefore, I will lay out more than the broad contours of the differences in work organization, or even management's theory of those differences. Rather, these chapters attempt to make a clear and grounded statement of the activities which were similar and different in the two plants (chapter 6) and locate their differences in the history, managerial strategies, and institutional environments of the plants (chapter 5).

Chapter 7, the first in the section on performance differences, adopts a multiple-stakeholder model to ask what criteria should be used to assess performance. I conclude that the capacity to prevent exceptions, and manage those which do occur, is the fundamental determinant of plant performance for virtually all stakeholders. This is not only for the traditional reason of minimizing uncertainty, but also because the ability to control the plant is a precondition for virtually all innovations which stakeholders might demand. However, I also acknowledge that other measures, such as morale, will not be affected by this. In the second half of the chapter I examine accident causation and safety management to demonstrate that high performance can be achieved other than by preventing exceptions from occurring in the first place, and many of the activities in the plants can be understood in terms of these secondary strategies.

The following five chapters then examine the plants' abilities to manage and learn from exceptions. I examine three different classes of differences between the plants: skills (chapter 8), stance (chapters 9-11), and flexibility (chapter 12) and explore the ways in which these affect the plants' abilities to perform the 12 activities. In chapter 8, I will argue that the worst employees at Wideplant had higher technical skills than their Highplant counterparts and that this led to fewer exceptions. I trace these higher skills to differences in recruiting, training, and conduct within the teams. In addition, the Wideplant personnel had higher interpersonal skills, which were vital for exception management and learning activities.

Chapters 9, 10, and 11 will examine differences in 'stance' and its impact on the organizations. Stance is a construct which is meant to convey the way people experience each other when they interact, and therefore the behaviors they are likely to adopt during such an interaction. I will construct it by aggregating the traditional variables of power differentials, trust relations, and the desire to control each other. I will argue that Highplant had higher (and more overt) power differentials, higher attempts by all people to control each other, and generically lower levels of trust. However, for reasons which can be understood by considering the technology and the history of the company, Wideplant was not as far to toward the other end of the spectrum as the reader might imagine.

Chapter 10 will then look at most of the twelve activities outlined above, and asked how differences in stance led to differences in their execution. We will see differences in domains such as people's discipline in completing routine tasks, their willingness to enact and
dealing with the problems they saw, their tendency to misattribute motives to others and therefore perform the wrong task, their tendency to impose their will on others capriciously, their desire to help each other, and their tendency to suppress information and learning opportunities. Possibly the most interesting of these will be the differences in the rate of attribution error. In addition to the politics of the organization being much worse in people's minds than it was in reality, this also meant that people were likely to carry out risky activities that were not asked for, but they thought were.

While chapter 10 will examine differences in behavior, chapter 11 will examine differences in the thinking which underlies behavior. I observed and will describe three types of rationality, which I will call practical (knowledge derived from beliefs), formal (knowledge derived from power relations), and accretive (knowledge derived from precedent). Formal and accretive rationality are complements and tend to be found together. Formal rationality was the second way in which politics and cognition interacted on the sites (with attribution errors being the first). Most activities on the sites were both formally and practically rational. That is, the actors considered them sensible, and their bosses did too. However, we will see that there were places where the two rationalities diverged, with Highplant tending toward formal/accretive rationality and Wideplant toward practical rationality. This created (different) performance advantages and problems at both sites, and these will be described.

The third driver of performance differentials was differences in flexibility, which I will define as the capacity to cope effectively with variations in the institutional environment or the strategies of actors. I will argue in chapter 12 that flexibility is created by having either multiple routines available for the completion of a given task, or multiple resource pools to draw from when solving problems. I will then illustrate the way differences in flexibility led to differences in outcomes in the plants.

Chapter 13 will begin the third part of the dissertation, which will discuss organizational change, by presenting a brief history of change in the two sites from about 1970 until the time of the study, and will characterize Wideplant as being relatively successful with a change effort which was initiated by a strike in the early 1970's. Highplant, on the other hand, will be characterized as much less successful.

Chapter 14 will describe what it means for an individual in an organization to change and will extrapolate from that to what it means for an organization to change. I will describe political and cognitive changes as two broad classes. However, I note that, because of problems of attribution error and formal rationality, these two categories are by no means distinct. Problems of formal rationality and attribution error also suggest that traditional change models, which assume the pure forms and ignore the implications of selective change (discussed in chapter 15), are likely to be inadequate. So, the bulk of the chapter lays out a framework for describing what adaptive cognitive change means and can be seen as the first step toward a critique of traditional change models.

Given the description of what adaptive change means, in chapter 14, chapter 15 asks how it is achieved. The chapter is organized in terms of two broad change strategies, namely selective change, or replacing the people you have with the people you want, and adaptive change, namely helping the people you have to become the people you want. The chapter simply lists the strategies which I observed people using as they tried to change the organizations. Within the adaptation approach, they employed three strategies: teaching people the new organization, proactively restructuring the organization so people would have different experiences, and strategically exploiting sense-making opportunities. When the selection and adaptation approaches were applied simultaneously, a third set of approaches
emerged. Of particular importance in this category was the use of selection to provide prototypes of people and organizations on which people who were trying to adapt could model themselves.

Chapter 16 will discuss the various barriers to change I observed. I will frame the chapter in terms of a hypothetical effort to persuade some production operators to adopt a new principle which guides their work. In addition to the barriers created by formal rationality (which tends to lead to institutionalized change) and attribution error (which reduces trust in the change process), the chapter highlights barriers created by diffusion processes within the operator group, and therefore reference group effects, the need for people to learn what is really meant, and conflicts between the need for ongoing production and the need for change, particularly in a context where only a portion of the crews have bought into the idea of the new organization. In addition, we will see how ambiguity and conflicts between objectives meant that no one was quite sure what was wanted, or whether people could deliver on their promises. Embedded in the argument is a critique of the “best practices” approach to organizational change.

Chapters, 17 and 18, will pick up one of the strategies identified in chapter 15 -- strategic sense-making -- and elaborate on it by analyzing the investigations of four equivalent accidents. Chapter 17 will deconstruct the incident investigations and show the way in which the final causes decided upon by the investigation committees, while clearly valid, had more to do with political strategies than the actual causation of the accidents. The accident causation process is often much too ambiguous to privilege any one cause over the others logically. However, we will see that the procedures the plants used, the way they categorized the data, and the normative emphases they put on the evidence led them to choose causes which happened to be consistent with their human resources management strategies. However, we will see how this provided much more than a rhetorical tool for management. An investigation opens up the organization’s self understanding for questioning -- cause and effect are temporarily decoupled, and therefore, so is the network of understandings on which the organization is built. If the reconstruction can be construed as being legitimate, change will result.

Chapter 18 will then take three of the four accidents and trace their implications through the organizations. We will see how the Highplant strategy of decentralizing safety and emphasizing individual accountability changed the organization, but not in the desired direction. Instead, it reduced morale and increased the amount of alienation of the production employees from management. At Wideplant, the investigation led to the creation of a task force to redesign the organization. While this task force did recommend some changes to the organizational design, and did identify and surface some of the conflicts inherent in the current design, the whole process started to move out of control by the end of the study.

Finally, chapter 19 will present some conclusions, research implications, and practical implications.
Appendix 1.1: The sites

Highplant had about 25% more capacity than Wideplant. Each plant employed about 70 production operators, 30 mechanics, electricians, and instrumentation technicians, 15 foremen, and 10 to 25 engineers. Each plant had three major process areas (A, B, C), two minor ones, (B2, B3) and four that were shared with other areas on the site (A2, A3, D, E) (see figures 1.1 - 1.3). Traditionally, the first of the three main areas (A) was managed as one organization and the second two (B, C) were managed as a second. However, Highplant consolidated the management of the two groups just prior to the study. Each of the two areas also managed a number of site-level functions. Furthermore, Highplant also managed the subsidiary processes (B2, B3) while the product of B2 was purchased by Wideplant and B3 was managed elsewhere on Widesite. For logistical reasons, operation A3 was much more difficult and labor intensive, and less reliable, at Wideplant.

Highplant had newer equipment, having been significantly refurbished in the late 1980's. The site was older, however, dating to the late 1940's. Wideplant was built in the early 1950's and had been progressively upgraded since then. The plants resided on large company-owned sites. Highplant's site (Highsite) used about 2200 employees and 1000 contractors to make about ten families of products. At the Wideplant site (Widesite), 700 employees and 200 contractors manufactured eight families of products. Five product families were common or very similar at the two sites. Scales of operation differed however.

The sites differed principally in their work organization. Unionized Wideplant was attempting to operate with relatively autonomous self-managed teams. This was a dramatic transformation from 1970 when Widesite had 13 layers of hierarchy (versus the current five) and 1400 employees producing half the current output. It was a very confrontational, traditional, unionized site with all the attendant management difficulties. The organization had evolved progressively since a long and acrimonious strike in the early 1970's. Through the 1970's, management worked to restore industrial relations. In the mid-1980's a new process area (elsewhere on Widesite from Wideplant) started up with self-managed teams, and a second started up a year later. In Wideplant, shift foremen were eliminated two years after that. Other elements of the work system changed since then, moving towards the organization of the two startup plants. The organization was still very much in transition at the time of the study, and would be for at least another decade.

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6 Highplant has more engineers, in part, because the refurbishment was incomplete at the time of the study. Wideplant eliminated three supervisors' positions during the study.
Figure 1.1 The "Compound" process, with Highplant highlighted (major flows only).

Figure 1.2 The "Compound" process, with Wideplant area A highlighted (major flows only).
Highplant was a fairly traditional, hierarchical, non-union operation. It had made two attempts to implement a self-managed work organization. In the early 1980's, as at Wideplant, the site introduced 'Organizational Effectiveness' training. They retreated from the program a couple of years later when safety performance and productivity started to lapse. In 1990, one of the area B and C crews (two work teams) trained on a stripped-down version of the Wideplant model. They implemented the system for a short period and then retreated to a conventional shift. In the meantime, in response to lapsing safety performance, site management attempted to implement a different type of change, namely a return to traditional safety management techniques.
2. Research methods

Data collection

While collecting the data, I set several objectives, to be satisfied simultaneously. They are presented below in decreasing order of formality of the data collection method.\(^1\)

Initially, I spent nine weeks at Highsite, with about four weeks in Highplant and five in another process area. Then, there was a break in the data collection while we re-negotiated access. I decided to divide the remaining data collection into three chunks. I went to Wideplant for eight weeks, and had planned to go back to Highplant for six and then Wideplant for six. I hoped that by alternating between the sites I would be able to make much better comparisons. This was a very successful strategy. As the data collection proceeded, I realized that six weeks was not long enough at Highplant. Also, the meeting schedule of the corporate group I was also studying made it much more sensible to stay for eight. (I could reduce the amount of travelling by going to the bimonthly corporate meetings between the site visits.) So, I negotiated to stay at Highplant for eight weeks, then return to Wideplant for another

\(^1\) Nothing was particularly spectacular about the data gathering process except that I took a lot of my observational and informal interview notes directly into a laptop computer. This enabled me to get a virtual transcript of meetings or informal interviews. I was surprised by the extent to which people did not appear to mind this approach. They seemed to accept that I wanted to take notes and appreciated that it was much easier for me that way. I don't believe that people were any more reactive than they would have been if I had taken notes onto a pad and then transcribed them. The major drawback of this approach is that I would often get very good micro-level data but the 'big picture' would be missing from the field notes. It was important to remember to go back and describe what was going on. In addition, I taped all the formal interviews, transcribed key ones, and collected whatever materials I could along the way.

Most days, I would arrive at the plant at 7:45-8:00 and finish up the previous night's notes, go and chat with someone, or go down to the control room and see what was going on. Then, I would go to the morning meeting and whatever meetings followed from that. That would take until about 10:00 at both plants. Then, I would attend meetings, conduct interviews, or do observation work until about 2:00, with lunch in the middle. From 2:00 until about 6:00 or later, I would work on my field notes. Sometimes I'd do observation work and interviews until about 4:00 and the write-up would take longer. In the evening I'd go into the control room and spend time with the operators. I would leave at about 10:30 p.m. I found, initially, that turning up in the evenings and on weekends was very important. There were two reasons for this. First, there was often very little going on, and people found it more interesting to talk to me than to stare at the control panel. Second, and more importantly, I was able to point out to the operators that I couldn't possibly be a spy because the corporation couldn't afford to pay me overtime for the sorts of hours I was working, just to talk to them about hunting.
four. This meant that my first visit to Wideplant was in the Winter and the second was in the Summer. I made a final four-week visit to Wideplant the following Winter (February 1994). This gave me a total of seventeen weeks at Highsite, with twelve weeks at Highplant and fourteen weeks at Wideplant. My access to Highsite was terminated when the relevant Vice President lost responsibility for the site in a corporate re-organization.

Progression through the organization

First, I wanted to know about progression through the organization. That is, how were people recruited, promoted, and trained. I conducted a series of formal interviews with people throughout the plant site, both in the various groups (operators, mechanics, engineers, managers) and within the plant staff, to answer these questions. The interviews of the operators and mechanics were carried out in the context of casual conversation, while with the engineers, it would be casual conversation or sometimes a portion of a formal interview about something else. With the managers it was always a large portion of a formal interview. The formal interviews were fairly open-ended and semi-structured. I would ask the people in staff positions first about themselves, and then about the subject of the interview. I would prompt for specific examples and details and we would explore the various dimensions of the topic. It took between 90 minutes and two hours to discuss a single topic like "recruiting operators and the mechanical trades." In addition, whenever I interviewed someone for the first time, I would ask about the person's employment history. This enabled me to compare the training and progression systems I was told about with those in practice and, by talking to people of different ages and organizational positions, about the difference between current and past practice. It also proved to be a good way to relax interviewees and learn about peripheral topics.

Safety, energy, and environment

Second, I wanted to know how safety, energy conservation, and environment were managed (though the latter two subjects were subsequently dropped). Therefore, I conducted a number of interviews with people responsible for those functions both in the plants and in the various staff roles. In addition, I attended meetings of the various site-wide safety committees at the two sites. At Highsite, this included the site-wide safety, health, and environment committee, the safety, health, and environment leadership committee, the process safety management committee, the employee safety awareness committee, and the staff meetings of the plant safety staff. Safety was also discussed at the managers' weekly meeting. In addition, I attended a supervisor safety training session.

At Widesite, I attended the site safety, health, and environment committee and the joint health and safety committee. In addition, I attended a facilitator safety training session and a process safety management training session. I also attended whatever safety-related activities I could in the plants.

At Highplant I attended safety audits, monthly safety meetings for the day personnel, weekly safety meetings for the shift personnel (each crew had one meeting a month), incident investigations, and the area safety awareness committee meetings. At Wideplant, I attended safety audits, safety meetings, safety training sessions, incident investigations and meetings of the two plants' area safety committees. In addition, safety was discussed at the regular meetings of the plant core groups and the business leader's weekly meeting with the coordinators.
Behavior between members of different organizational groups

Third, I wanted a comparison of behavior between members of different organizational groups. Therefore, I attended whatever morning meetings I could. This enabled me to keep abreast of what was going on. It also enabled me to have one activity with a multiple repetition, controlled comparison of the two plants. Often, the morning meeting was followed by a second to discuss the problem of the day. I would attend that too and many other meetings involving people from different groups in the organization.

Experiences of work

Fourth, I wanted to know how work was done and how people experienced their work. I learned about this by opportunistically attending whatever meetings were going on, by following people around as they worked, by watching activity in the control room, and by asking lots of questions. In particular, I spent a lot of time in the control room just chatting to people about whatever came up. While this meant a lot of time discussing religion, politics, or people's prejudices about race, gender, or management, I was often able to direct the conversation towards work-related issues. Furthermore, at the start of the study, people volunteered to 'be interviewed'. They often had a pet peeve which they wanted to tell me about. Presumably they saw me as a conduit to management. I would let them tell me about whatever they thought was important and I would simply ask whatever questions came to mind as follow-ons. While this sounds fairly loose, the follow-on questions would often be attempts to triangulate people's claims, generally by asking for examples. Often, people couldn't provide examples, so their theories were rejected. If there were examples, I would probe for attribution errors or alternative explanations of the phenomenon they were making a claim about. The reader will appreciate from the discussion in chapters 10 and 11 that I did not assume the theories to be truth. However, this exercise served a number of valuable purposes. First, it pointed me rapidly to the problems of attribution error in the plants (chapter 10). Second, it gave me a good database of events which people in the plant thought were important. This helped me construct histories which reflected the operators' perceptions. Finally, it directed me to the contentious parts of the organization's activities. After several months of working and interacting with the tellers of the stories, I was able to make a broader judgment about their validity. For instance, we'll see in chapter 10 examples of a theory from a Wideplant controller who consistently made huge attribution errors. I have held everything he said very lightly (or cited him as an "unreliable source"). I also developed a much better understanding of the activities in the plant. Later in the process, I became much more directed in the questions I asked. However, because the data collection occurred in a relatively short time, I felt forced to ask many more questions than I would have liked, rather than just watching what was going on.

Events

Finally, data collection focused on events -- the unit of analysis for the study. An event begins with a rapid increase in activity focused on a particular stimulus and ends when the stimulus goes away or is redefined.

There are three reasons why the event is the appropriate unit to use.

* It was one of the principal ways in which people in the plant partitioned time and understood their histories. (See chapter 4.)
* There are sound theoretical reasons why it should be important. In particular, those areas of organizational theory which focus on uncertainty, exceptions, or discontinuities would select it as their unit of analysis (e.g. Perrow 1967; Thompson 1967; Argyris and Schón 1978; Tushman and Romanelli 1985).

* It is the likely place where change will occur. Routine operations tend to be highly institutionalized, and therefore likely to operate virtually independently of organization-specific variables. We can see that they have different procedures at Highplant than Wideplant. We can see that they are more or less likely to obey procedures at Highplant. However, we are unlikely to see organizational change through the procedures or other routinized actions.

When these three observations are combined, we can see that the event is the appropriate process variable to use in a study of the plant. There are, however, three problems.

* While the definition is very clean on paper, events are often difficult to separate, since they tend to be part of a stream of activity rather than being discrete.

* No two events are a priori comparable. First, they will not have the same precursors. Second, even if two events were physically comparable, an 'exception' (Perrow 1967) doesn't become an 'event' until it is enacted. One organization may not enact a given exception as an event, or if both do, the two organizations may enact it differently. For instance, one may devote a lot of effort to learning from it, and therefore leave a paper trail, while the other does nothing other than deal with the problem and move on. Enactment is not trivial. In two process areas (one at each site), a change in area managers led to an instantaneous four-fold increase in the number of incidents investigated. As such, direct quantitative comparisons of performance, using some measure of events, would not be possible, even with identical technology. Hence, we cannot say that 'This plant is better than that because it has fewer events.'

* Events vary with the technology. Highplant had more alarms than Wideplant because it had a digital control system (DCS), which was much more sensitive than a pneumatic control system and had more meters. Wideplant, on the other hand, had much more, smaller, and older equipment, so we expect more routine mechanical problems. Highplant's process 'C' was relatively new, so we expect non-routine problems there as the kinks are ironed out and people learn to use the equipment.

Whenever things happened in the plant, I would try to gather as many perspectives as possible on what had happened, what was happening, what was going to happen, and why. In addition, I conducted a number of interviews around the management of the accident investigations discussed in chapter 17.

Event enactment

In addition, I attempted, unsuccessfully, to determine what sorts of exceptions people
considered to be events by trying to determine, in practice, how people defined incidents. The methodology I pursued and problems I encountered are discussed in chapter 11.

Problems with this approach to data collection

While this comprehensive approach to data collection appeared to be sensible at the start of the study, there were four problems with it, two minor and two major. The first minor problem was that the focus on events meant that the data gathering had to be opportunistic. I had to wait for events to occur before I could gather data on them. This meant that it was not possible to be systematic in the comparative parts of the study. If I scheduled an interview or decided to attend a safety audit, and an important meeting was called to deal with a problem, the problem would have to be sacrificed. If there was not much going on, I would focus on much smaller events. The second minor problem was that it was often very difficult to get multiple perspectives on a given event because, by the time I got to talk to a key player, three more things would have happened.

The first major problem was one of organizational politics and trust. The data gathering approach I selected meant that I was constantly changing the hierarchical level in the organization at which I was obtaining data. This meant that it was virtually impossible to develop good trusting relations with people, particularly at Highplant. Everyone thought I was a spy for someone else. Operators thought I was spying for management, people in management thought I was spying for the corporation as part of the reengineering initiative, or as part of a proposal to sell a business, people at Wideplant thought I was spying for Highplant, and so forth. To my surprise, the most defensive people were not the production operators. When the Highplant operators stated their concerns explicitly, I gave them a copy of my proposal to read, and then they were very open. The problems were much more severe with some people (not all) at higher levels of the organization. Those who did not think I was a spy were worried that I would say something about them that would undermine their careers. In the end, I don’t think I ever gained true access with more than a few people at each site. This is a major weakness of this research.

The second major problem was that I was never with any one person for long. This meant that it was very easy for me to miss the ‘real action’. There were two reasons for this. First, a lot of the real work happened in the corridors and by e-mail. Since I was rarely in the corridors with other people at the right time to learn about the problem solving for the particular event for the day, and I didn’t get a chance to look over people’s shoulders as they read their e-mail, I missed a lot of things. Second, in parts of Highsite, there is a tradition of interpersonal conflicts being resolved behind closed doors, often at high volume. I don’t know the extent to which this is the case at Highplant since people could easily manage such events out of my sight. I doubt such screaming matches occur at Wideplant. I didn’t realize these problems until it was too late in the study to do anything about them.

Data analysis

Data analysis began as soon as data collection began. I attempted initially to use formal ‘grounded theory’ techniques to develop appropriate categories for the data (Glaser and Strauss 1967). However, this task rapidly became overwhelming. I found that there was so much going on in the plant that I could open code any section in the first three weeks of notes
and have different codes to virtually any other section. Therefore, I set myself the much simpler initial task of understanding what was going on. Later, I developed an appreciation of what the differences were between the two sites and used much more grounded techniques to work out why those differences were occurring.

Although I wasn’t using formal grounded theory techniques, the data collection involved a constant conversation between myself and my field notes, colleagues (when I was feeling rich or lonely), committee members, and people in the plants. Sometimes, I would write memoranda in which I laid out parts of the theory. More often, I would simply put footnotes in my field notes with questions which could be asked or observations which could be made to test that set of hypotheses. I would then endeavor to follow up on these.

In retrospect, this approach was a little too casual. I found that I was having my best thoughts while driving to or from the plant, or walking around the plant site. Given this, it was very easy to not write them down. Or, if I did write them down, not to link it in the memo to the data which were driving the insight. One of the problems I had with the field work was that the onrush of information was intense. It was very easy to not write observations down and think I had. Nevertheless, when I sat down to write up the dissertation, I was able to reconstruct most of the insights I had in the field, and their justifications.

To analyze the data, I reread all the field notes and other materials I had gathered. As I did so, I divided the field notes into natural time periods during the day, such as an interview, an event in the control room, a discussion, or a meeting. Then, using a hypercard-like computer program I wrote cards about each time period, summarizing what I had observed or learned, and being careful to note with whom I had been speaking and to use a consistent vocabulary to describe events. In addition, I retyped any analytical notes from my field notes onto a separate card in a card stack of analytical notes. As I typed the cards, I wrote up a card for any thought which came to mind. In addition, I kept an eye out for events at one plant which had parallels the other. I noted each of these on a card of their own also. So, for instance, I would identify similar physical events, such as a tank overflowing, or a dryer breaking down. Alternatively, I would identify similar interpersonal events such as someone being asked to do something unsafe.

This gave me a stack of analytical notes and several stacks of summaries of the field notes. I could use the field note summaries in three ways. If I sat down and read them, it was possible to recall the content of original notes in detail. This meant I could actually keep a large quantity of data cognitively accessible at once. Alternatively, if I wanted to know about a particular event or object, I could pull up every card which referred to it by simply searching for the string. So, for example, if I wanted to know about ‘lockout and tagout’ I could search for the character string ‘tag’ and pull up every reference to the procedure in the field notes. I could then simply re-read the relevant field notes. Finally, if I wanted to recall a particular conversation or event, I could search the database until I found it. Then, I simply had to re-read the relevant field notes.

The primary mode of data analysis was to construct matched pairs of events. That is, for every analytical point I make in the dissertation, I have tried to pull from the database pairs of events which are arguably very similar, if not identical. By examining the way people in the plants reacted to those events, I believe that I can compare the sites honestly and that another analyst would reach the same conclusions. I have avoided picking and choosing examples to substantiate a given point independent of its overall relevance. This is a tremendous temptation because the differences between the sites are not crystal clear. There are examples at both sites which are contrary to the general assertions I make. Where those counter examples are important, I have generally included them.
Furthermore, I have tried to triangulate the data analysis by using different examples whenever possible. Triangulation is achieved in two ways. First, careful readers will note that I often make points when there are already many examples in the text which substantiate it. However, I introduce a new example each time so the reader can get a feel for the depth of the evidence behind a given step in the argument. Second, if the argument is logical, then all its steps should form a coherent set. Therefore, while any given point may appear to be relatively 'impressionistic', the total corpus forms a fairly solid analytic whole.

In theory, it should be possible to quantitatively analyze the data in two ways. First, an analyst could go through each set of notes and extract a comparable subset of observations and interviews. The two subsets could then be coded for examples 'for' and 'against' each claim I have made which differentiates the sites. The resulting database could be analyzed statistically, either by analyzing the total 'fors' and 'againsts', or by analyzing the 'fors' and 'againsts' for each claim. Second, I could code each set of field notes in terms of whether observations were differentiating for, differentiating against, or neutral to the theory as a whole. This would give a 'truth fraction' for each site. I haven't bothered to complete either task because I believe the argument is convincing enough as it is.

Some reporting conventions

1. Most quotations are followed by a number (e.g. 921104). This refers to the date of the interview or conversation.

2. It has been very difficult to deal with both gender and confidentiality. I did not want to turn all the women into men because I believe that gender is an important determinant of the way people are perceived and the way they act. However, there were often too few women in the workforce to be able to identify people as women and protect their anonymity. Therefore, unless it was safe to do so, I have studiously avoided using pronouns with the women, and have been as vague as possible with the men. Consequently, some people in the plants will appear to be genderless, others will appear to be men, and women will show up in unexpected places.
Appendix 2.1: Study design and access

The study began as an exploration in organizational learning. In particular, I was interested in understanding how Transitech, which claimed to have expertise in safety management, was using that expertise to learn how to manage energy conservation and environment. On this basis I approached the company, through a contact made by one of the faculty in the MIT Organizational Learning Center. The contact liked the project and took it to his supervisor. The supervisor, who became the study sponsor, asked to meet me, so I wrote a proposal and we then met for several hours. He was intrigued by the project and saw it providing results which fit well with his portfolio of responsibilities. We agreed that data gathering should have two components. One would be to follow the progress of the corporate energy management group which was trying to develop and implement a corporation-wide energy management strategy, while the other would be to conduct a comparative study of two plants. He arranged for me to address a meeting of plant managers, and one plant signed on for the study. He assured me that the second was on the verge of agreeing, and that it was technically very similar to the first, so we decided to proceed with the project, with Transitech paying a small stipend and my transportation costs.

That project rapidly became unstuck. First, the second site fell through. That site had participated in another study some time earlier, and management had been very unhappy with the publicity that had come from the findings. They did not want to risk another embarrassment. I searched for other sites in the corporation which would be technological matches to Highsite. Widesite was an obvious choice, since it manufactured a number of similar or identical products. It was also potentially very exciting -- much more interesting than the original comparison site -- because its workplace innovations were famous within Transitech. Therefore, I set about negotiating access into a couple of process areas at Highsite which were matched at Widesite, with a view to negotiating access there too. These negotiations went smoothly. Second, I found that there was very little energy conservation work going on at Highsite. In Transitech’s U.S. operations, if you don’t have power, it is vital that you have the sponsorship of someone who does (see also Jackall 1988). The lack of energy conservation work undermined my sponsorship, and therefore my legitimacy.

The main problem arose, however, from a conflation of three factors: the environmental component of the research, my previous research experience, and my research style. In essence, when he granted me access, the site manager had not appreciated the sorts of environmental data I would require to do a thorough job and decided, for various reasons, that he did not want to risk having those data publicized. Furthermore, a prior research project of mine had involved Highsite and an aspect of the plants’ organization which I wanted to study as part of this project. For various reasons, this made the site manager nervous. Finally, an aspect of my research style ran contrary to the site culture and made the site manager anxious. I decided to remove myself from the field and construct a project which would be more amenable.

I spent the next month in Boston working up a new proposal. Tom Kochan and I went to corporate headquarters and met with my sponsor, the site manager from Highsite, the business manager from Wideplant, a representative of the corporate energy organization and the person who facilitated my access at Wideplant. I presented a proposal to examine the way in which organizations can change without jeopardizing safety or environmental performance. They asked questions and presented their concerns, and we discussed them. Then, Tom and I were sent out. When we returned, they insisted on putting four conditions on the research. First, they
wanted me to drop any discussion of one functional area. Second, they wanted me to drop the environmental component. Third, they wanted me to agree to not publish anything other than the dissertation. Finally, the Highsite manager wanted Vice Presidential approval. I accepted the first condition immediately, said I would think about the second, and refused the third.

We ended the meeting with me promising to write a revised proposal. If it was acceptable to them, they would take it to a higher authority. Environment was dropped, and the condition on publication was changed to a promise to not write a popular book. The proposal was acceptable. I met with the appropriate Vice President a month later, and was back in the field a week after that, examining the relationship between safety management and organizational transformation.
3. What is a chemical plant?

In this chapter, I will describe the technology in a chemical plant as the complex interplay of four systems: the production system, the steam system, the control system, and the safety system. Along the way, I will discuss the operations of those systems and the reasons why it is so difficult to make 'compound'. Through the elaboration and exemplification of these technical aspects we will see that, despite their apparent similarities, there are important technical differences between the plants.

The production system

Chemical processes consist of a series of steps which are generally called unit physical operations and unit chemical processes. Unit physical operations do not involve a chemical reaction. They include operations such as unloading, loading, pumping, packaging, washing, drying, mixing, and grinding. In unit chemical operations, the material is transformed. Chemical operations include dissolution, separation (e.g. distillation), esterification, crystallization, and oxidation.

In its crudest outline, the process for making 'compound' is a simple string of unit operations. Raw materials are unloaded in process A2, and reacted with the product of process A3 and distilled in process A. This results in three streams of output materials: one is sent to process B, one to process D, and one to process E (the waste treatment plant). The stream sent to process D is oxidized and one of the products is sent back as an input to processes A, B, and C. Process B2 is also an oxidation process. Its product is mixed with the product of process A and they are reacted in a converter to produce a solution of 'compound', some by-products, and the initial reactants. This solution is crystallized, washed, dried and redissolved a couple of times until it is adequately pure, and then it is dried, loaded into rail cars, and shipped off site. Some of the by-products are reacted into another product (process B3) and others form a waste that is sent for treatment (process E) or released to the air (see also figures 1.1 - 1.3).

Between these various steps are storage tanks which buffer the processes from each other. Between the major processes (and therefore between administrative units), there is generally storage for several days of product. Between the steps in each process, the holdup capacity is much less, generally about a day's worth. The tanks between the processes are larger for a couple of reasons. First, it is quite common for a process to have operational difficulties or shut down for a few days for maintenance. The large tanks enable the processes to be effectively decoupled (Thompson 1967). Second, at various times, the different processes have different relative capacities, modes of operation, and reliabilities. Therefore, it is important to have storage tanks which will enable small reliable plants to run continuously while big semi-continuous plants start and stop. However, a new trend in chemical process design is to minimize these buffers (cf. Womack, Jones et al. 1990). I will discuss this further in chapter 11.

Beyond these relatively simple linear processes interspersed with tanks, four aspects of chemical plants' design make them much more complicated. First, chemical plants evolve: bottle-necks are removed, better ways of completing each step are developed, capacity for minor variations in product are installed, minor process improvements are found, old equipment
is replaced, and capacity is added, often by duplicating parts of the process. Although, at the
time of the study, Wideplant was nominally the same plant as was constructed in the 1940's, its
capacity had increased sixteen-fold. Second, the plant isn't linear: to save money and energy,
process steam is recycled, as are solvent streams, partially reacted reagents, and waste heat. In
some cases (as with process D), these recycle loops extend beyond one production unit: Two
plants will use each other's outputs as inputs. Third, over time, people find uses for waste
products, and so side processes are added to convert the waste products into saleable
commodities, as is the case with process B3. Finally, the plant cannot simply discharge waste
streams to the atmosphere. A large portion of the hardware traps and treats pollutants,
especially gaseous ones.

These four aspects of the plant's design -- a history of additions and changes, return
loops, the development of side processes, and the addition of innumerable pollution control
devices -- makes even the simplest process extremely complicated, with a virtually
incomprehensible process diagram. Production of 'compound', being a complex operation,
contains over a hundred different physical and chemical operations, enmeshed in a spaghetti
of pipe-work.

The steam system

This spaghetti is also very complicated. In addition to the pipes that link the various
physical and chemical operations, and three or four trunk lines of steam that is used to provide
heat for the process, there is a mess of steam tracing: small pipes full of steam which are
wrapped around any systems which are temperature sensitive (such as meters) or contain
material which can freeze. The steam tracing is interspersed with steam traps: devices which
prevent condensate accumulating in the lines.

The control system

The process operators' principal goal is to 'line out' the process. Each of the one
hundred or more operations is controlled by three or four variables (temperature, pressure,
production rate, depth in the tank, etc.). The process operator aims to keep the relevant
variables constant for all the operations in the entire production process. To do this, the
operators must open and close valves and turn on and off machinery to regulate temperatures,
pressures, and the like, and hence the rates of production and reaction. To perform this task
adequately, the operators need an overview of the plant's operation. Therefore, as soon as was
technically possible, chemical plants began to centralize monitoring of the process in a 'control
room'. When Highplant and Wideplant started, the control room was almost exclusively for
monitoring. The control room operator would observe the dials and telephone instructions to the
various field operators, who would open and close valves and start and stop machinery. Field
operators still spend a portion of their time on these tasks.\footnote{Manual handles are used on isolation valves, valves which aren't used to control the
process in routine operation, and some smaller valves. A lot of the machinery is still
started in the field to ensure that it runs properly.}
Pneumatic control

Subsequently, three generations of technology have been developed to control the process remotely. With the first, pneumatic control, the control room operator works 'on the panel', a long array of meters and alarm lights along the control room wall which show the status of various variables. Many of these gauges have pen-recorders attached so operators can reconstruct that variable's history. Attached to the valve gauges are a pair of knobs and a switch. One knob adjusts the set point for the equipment if it is operating automatically. The other facilitates manual operation. The switch allows them to move from one mode to the other. Similarly, many of the alarms contain switches to operate the relevant equipment. For instance, the alarm for a pump going down will contain the 'on' switch for that pump.

Each meter is connected to its equipment by two tubes filled with 'instrument air'. One tube transmits, with a transmitter, the state of the variable to the meter. The other transmits the operator's instructions to the equipment, via an actuator and a controller. Therefore, in addition to the process piping and the steam system, a third piping system for instrument air runs through the plant.

Direct digital control

The second generation of control technology involves the use of 'direct digital control'. With a direct digital control system (DCS), signals are transmitted to and from the control room electrically and are monitored using a microcomputer, although instrument air is still used for metering and actuation. DCS is simultaneously a boon and a burden. The DCS systems are much cheaper to operate since the equipment is much more accurate (because there are no pressure losses in air lines), reliable (because wires don't leak), and contains fewer moving parts. Therefore, maintenance costs are much lower. Furthermore, it is possible to program the system to do certain things, such as open a valve at a uniform rate over a 90-minute period. This is much easier to do than remember to inch it open 10% every ten minutes. Third, with the digital systems, it is possible to monitor and control many more variables than with the pneumatic systems. For example, when area 'A' at Highplant installed its DCS system, they added 300 transmitters to the control system. Finally, DCS's have tremendous data logging capabilities. They can record not only the history of all key process variables, but also the control steps taken at a given time and the alarms that occur. These histories can be used to reconstruct events for learning purposes -- in the view of management -- or to lay blame on the operators when things go wrong -- in the view of the Highplant operators.

However, DCS has two very big down sides. First, the operators complain consistently that the technology prevents them from viewing the process in detail, as a totality. They could stand back from the old panel and literally examine the whole operation. In comparison, with the LCS, they felt like they were operating through a tiny little window into the process. One Highsite plant had a very difficult start-up operation. At the time of the study, when their DCS was being designed, the operators wanted management to install enough DCS monitors to reproduce the old pneumatic panel for startup. Forty monitors would be needed instead of the usual eight or so. If this is representative, it means that DCS systems provide only 20% of the information of a traditional panel at a given time. Second, the operators complained that because the DCS would operate without the operators keeping the whole process in mind at once, it was much harder to train new panel operators to operate the system skillfully. Instead of learning how to control the process, they tended to learn how to react to the DCS.
Intelligent control

The third generation of control is known as 'intelligent control.' While this comes in many forms (e.g. "Neural networks", "Optimal process control"), intelligent controllers differ from conventional digital control in that they operate on several variables at once and use a computer algorithm to determine the correct setting for the control variable. For example, the best setting for a valve may depend on the values of two process variables, the production rate, and the outside temperature, all subject to a feedback process which takes 15 hours to come to equilibrium. Such a system is very hard for a human to control optimally, and so a computer is used instead.

On the one hand, intelligent control is a potential panacea. The technology of chemical manufacturing is so complicated that it is very difficult for a human operator to determine the optimal operation of a given piece of equipment. Each percent of productivity is worth literally millions of dollars. Similarly, in multiple product facilities (which Highplant and Wideplant were not), rapid and smooth transitions from one product to the next are worth a fortune in out of specification product which is prevented and stress on the equipment which is avoided. Therefore, computers which can take the guess work out of equipment optimization are extremely valuable. The down-side of this equipment, however, is that it is only valuable if the organization can run the plant in the first place. A very sophisticated control system which sits over the top of a poorly controlled conventional one will be worse than useless because it complicates the operation task. Furthermore, if the intelligent control installation at Wideplant is any indication, the actual installation and calibration of the controller requires a tremendous amount of cooperation between the operators, the engineers, and, to a lesser extent, the mechanics. Without that cooperation, an installation attempt is more likely to result in open warfare than reduced costs.

At the time of the study, all areas at Highplant were on DCS. Area A’s DCS was installed in the shutdown just prior to commencement of field work in that area. At that time, the control room was moved from another part of the site to the same control room at Areas ‘B’ and ‘C’, and the management of the three areas was consolidated into one administrative unit. At Wideplant, most of the process was still on pneumatic control. However, any processes that had been installed in the previous five or so years were installed with DCS. Full DCS conversion was slated for about two years after the study. The installation of the intelligent controller in Wideplant area ‘A’ involved about six months of calibration experiments prior to installation. They were still learning how to operate the controller properly eight months after installation was complete.² It was considered a phenomenal success.

Control room layout

The two plants had dramatically different control room layouts (figure 3.1). When they installed the direct digital control system in areas ‘B’ and ‘C’ at Highplant, they built a new control room which could also house area ‘A’. The three areas had always used the same control room at Wideplant.

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² In part, this is because a given operator can only expect to work about 60 weekday day shifts in a given year. There are four people per crew, so, after a year, they would have used the controller, with access to instruction from the engineer, an average of fifteen times.
At Highplant, the room was 'L' shaped and the control panels for the three areas were arranged to surround the operators. This meant that the operators from the three processes were effectively separated from each other. Two things made the separation much more complete than even the figure would suggest. First, the top of each DCS console was about five and a half feet above the floor. (The screens were stacked two-high). It was only possible for people in different areas to see each other if both stood. Second, the lights were kept off or very dim to reduce glare on the screens. Therefore, each area felt like an oasis of light in an electronic wilderness.

In the corner of each area was a television set and video player. I never saw a video player used. The site ran four closed circuit channels. One channel ran slides of corporate and site information. Examples included the names and photographs of corporate award winners, announcements of corporate financial performance, senior corporate promotions, and extracts from press releases and speeches by the C.E.O. One channel had short video presentations of important announcements by key people on the plant, key people in the corporation, or videos that site management thought would be useful to the people in the areas (e.g. 'hunting safety'). One had a weather forecast and satellite photograph of storm activity, and one showed a map of the plant and was used to map gas release plumes. The television was capable of picking up outside channels, but that was banned. Therefore, during important sporting events or presidential debates, people would sit around watching television, flicking it off whenever anyone walked into the room, and looking innocent, with all chairs facing the set. It was, of course, obvious what was going on, but the supervisors pretended not to notice.

The Wideplant control room was dramatically different. It was a large, light, rectangular room with the panels for the three processes stretching around three and a half of the four walls. Above the panel was a picture of the part of the process that set of dials controlled. As could be seen, instead of facing toward each other (i.e. with the VDT terminals in the middle of the room) the area 'B' and 'C' VDT panels faced outwards. This meant that there was complete and open communication between the two areas and that the panel operators could relieve each other if things were quiet. While the area 'A' VDT array was facing into the room, it was only one screen high, so it offered no obstruction to communications between the areas. There were no televisions, but the crews had bought themselves a stereo which frequently played local radio stations.  

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3 Several operators expressed concern to me about radiation from the screens, though corporate managers assured me that appropriate safety checks had been performed.

4 The company subsequently replaced this with a better system.
Figure 3.1 Control room layouts (not to scale)
The safety system

Alongside the main production system, the steam system, and the instrument air and control system, one more system complicated the operation of the plant: the safety system. In addition to the reticulated foam fire protection pipe-work, three different safety devices were used in the processes studied: relief valves, rupture disks, and interlocks. Relief valves and rupture disks are designed to protect vessels from excess pressure. A relief valve is designed to be used occasionally or to minimize venting, and, therefore resets itself. For instance, if one of the processes on the site were to go down unexpectedly, the demand for steam from the power house would drop precipitously. Because it is impossible to slow the boilers down quickly the excess steam has to be disposed of somehow. It would be exhausted automatically through a relief valve. Rupture disks are thin steel plates which sit in a vent tube attached to pressure vessels. If the vessel over-pressures, the perforations in the plate crack, and the rupture disk gets pushed out of the vent tube, followed by the excess contents of the vessel. Interlocks are electronic devices attached to the switches on mechanical equipment. If certain variables are exceeded, such as a reactor getting too hot, the interlock will trip and shut down the process. An average process area has 500 interlocks. Once an interlock trips, the equilibria of adjacent units will be upset and so their process variables will start to move out of control. Unless the operators are very quick, one interlock tripping can lead to a domino effect with large sections of the process interlocking out and shutting down.

Inputs and outputs

However, operating the plant is much more than simply 'turning the knobs'. In particular, the technical task of making compound requires that raw materials and product be managed. Raw material orders had to be coordinated with the plant tasking. Furthermore, at Wideplant, someone had to follow each shipment which came to the plant and each trainload of empty cars which left to ensure that there were always enough cars at each point on the supply loop. At Highplant, all the major materials came by pipeline.

Similarly, finished products had to be shipped off site. This involved two tasks. First, there was the logistical operation of ensuring that the right materials, of the right quality, were shipped to the right customer in the right packaging (rail-cars, tanker trucks, or bags). Second, insofar as the product was differentiated, people had to service the customers to ensure their needs were being met. The people who did this servicing were called 'customer champions'.

In addition to the raw materials and product management functions, five tasks had to be managed within the plant. First, there had to be an adequate supply of reasonably happy labor to work on any given shift. As we will see, particularly at Wideplant, this personnel management function was far from trivial. Second, maintenance had to be performed and coordinated with production. Not only did the production operators have to 'tag out' the equipment for maintenance, but the maintenance had to be performed in a way which minimized the disruption to production.5 Third, because the analytical instruments could not be

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5 Tagging out involved purging systems of dangerous substances, physically isolating them, and locking and tagging points of entry for these substances, and energy sources, in such a way that contaminants could not be re-introduced. Tagging out was a complex and arduous
assumed to be reliable and some parameters were not read on-line, samples of process fluids were taken and analyzed by the laboratory twice every shift. Fourth, someone had to assure that the plant operated in a safe, clean manner producing high quality products. Finally, new parts of the plant were constantly being designed, old parts were being upgraded, and systems were being checked for their safety. Later, we'll see that some of the principal differences between the plants were in ways these input, output, and production support functions were managed, rather than in production itself.

Operating the plant

Imagine an operator trying to line out a reactor whose key control variable was the level of material in the vessel. The operator would face the following constraints: First, there would be a desired level. If the plant were operated at the desired level, it would be most efficient. Surrounding the desired level would be the B.O.P.'s (Best Operating Parameters). It would be safe and acceptable to operate anywhere between these two levels. If the vessel crept out, then an 'B.O.P. violation' would have occurred. Above the top of the B.O.P. would be a high alarm. If the fluid rose above this level, an alarm would go off. Similarly for a high-high alarm. Finally, if the high-high alarm were exceeded sufficiently, a rupture disk would blow to evacuate the vessel and/or an interlock would close, and the process would shut down.

Maintaining BOP compliance was no trivial task. First, the control schemes for the plants were highly non-linear and very complex. Second, the time delays could be enormous. Control changes within the plant could take up to 10 hours to make themselves felt and the same again to come to equilibrium. Third, the older equipment tended to be very idiosyncratic. Finally, management was constantly pushing the operators to run the plant at the edge of its productive envelope. If the plant was up and running there was nearly always pressure to run at full rates. If it was down, there was pressure to get it up again. Each day down could cost hundreds of thousands of dollars in lost product.

While the above would make any chemical process sensitive to error, the 'compound' process was particularly sensitive. Operators claimed that it was the most difficult of all chemicals to make. They had two reasons for this. First, process 'A' was arguably the most hazardous of all chemical processes. The main reactor consisted of a 200' high tower full of an explosive mixture of hydrocarbons and air. A worst-case accident would be calamitous. Because of this risk of conflagration, the process was covered in interlocks and even small variations from its designed operation could shut it down. Therefore, the operators had very little room to maneuver.

The second, and major reason, was that process 'C' involved the refining and drying of the compound. Not only did this process have the potential to give off large volumes of

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process because the boundaries of the systems tended to depend on the maintenance operation being performed, every tag needed a hand-written description of the job, and a reasonably large piece of equipment would require at least fifty tags and locks. Once maintenance began, it was not possible to change any of the tags without ceasing work, so errors were either dangerous or expensive. The operation had to be performed in strict accordance with the procedure. The procedure at Highplant was significantly more complicated and difficult than that at Wideplant (see chapters 10 and 11).
poisonous gas, but the product was extremely sticky until it was completely dry and would quickly form lumps or attach itself to any surface. Mechanical failures almost inevitably resulted in a machine or some pipe-work full of 'compound', which then set in a lump. Lumps clogged the machinery or made it vibrate. If surfaces become frosted with product or gummed up with impurities, the solid was very hard to remove and required several hours of washing with steam or hot water. Often this required that a section of the process be shut down and tagged out so people could get access. The stickiness of the 'compound', and hence the risk of fouling, meant that the amount of pipe-work was minimized. Therefore, it was very easy for upsets to spill from one piece of equipment to the next. In addition, process C was a refining process. Unlike a normal chemical plant, where nothing moves except the working fluid and a few pumps, process 'C' comprised mainly mechanical equipment. As one supervisor joked, it was more like a laundromat than a chemical plant. This made the process harder to operate and maintain, and much less reliable. Finally, the crystals of 'compound' broke very easily. If the particles were small, the 'compound' had a tremendous potential for dust when being loaded into the rail cars and wouldn't unload properly. So, it had to be handled very carefully.

Because the equipment was very idiosyncratic, extremely complicated, had very high interactive complexity, and was generally operated on the edge of its capabilities, its operation was extremely sensitive to very small errors and oversights by the operators or the designers. Three examples illustrate this. First, at one of the plants, the panel operators had reduced the operating speed of one of the motors on a dryer to prevent an over pressure in the system. Subsequently, they shut down the dryer. When the operators on the next shift started up the dryer again, the panel operator forgot to check the operating speed. This was easy to do since operators had to monitor many variables and were often responding to alarms every few seconds. As a result, 50% more wet 'compound' was fed in per revolution than was usual. Eventually, the dryer interlocked out under the extra load, but by this time it was full of wet 'compound'. It took three days, at a cost of hundreds of thousands of dollars a day in lost product, to clean it out. Second, the new building 'C' at Highplant was fraught with operating problems caused by minor oversights during the design. For example, a designer rendered the entire dry 'compound' transport system inoperable by making one pipe radius too tight for the 'compound' to get around easily. Similarly, many of the operating problems in the plant were caused by problems with the design of the transitions from one piece of equipment to the next. In these cases, the engineers and operators had been unable to develop designs to which the wet 'compound' didn't frequently glue itself. The third and final example concerns the running of the plants during the week. Everyone 'knew' that the plant runs better at night and weekends. Generally this was because there were no minor perturbations, such as the engineers running tests or the operators (at Wideplant) or supervisors (at Highplant) being pulled away to meetings.

Given the incredible sensitivity of the plants to errors and the very high cost of rectifying mistakes, it should be no surprise that the plants exhibited very high returns to skill. In particular, if -- as a result of either individual or collective effort -- the operating capability of a given crew fell below a certain level, failures started to occur, and these failures rapidly cascaded to create expensive problems. For example, one of the operators at Highplant was generally considered to be among the least competent. I observed him operating the control console four or five times for a couple of hours each. In three of those five times, he either caused equipment to shut down (and other operators intervened to prevent a full shut down) or other operators intervened just before the calamity. Given that shut downs can take days to rectify and tend to damage the equipment, we can see the importance of high skills on a team.

The other important result of this very high complexity and idiosyncratic equipment is that no one actually understands the production process fully. When discussing plant dynamics, one engineer wrote to me:
... for example it was only recently understood in our (Wideplant) organization that the core process behaved NOT (the way we thought it did), but rather (the way we thought it did + something else). The result of this discovery changed the way we understand and expect to control the (core process). And we have been making 'compound' for 40 years! (941018)

At Wideplant there were two, or maybe three, operators who were seen as 'experts'. They were intelligent, had between twenty and forty years of experience each, and were extremely conscientious. However, even they told me about the limits of their understanding of the technology. The engineers would regularly seek out these operators when trying to solve problems. At Highplant there were many people who claimed to 'know' the process. However, I often observed them arguing to see whose truth would prevail and heard many comments about the lack of knowledge of key players. While Wideplant's strength was a group of very experienced operators, the engineering team at Highplant was one of the best developed in Transitech.

Conclusion

In this chapter, I have described the technology in the plants. We saw that it can be understood in terms of four systems: the production system, the steam system, the control system, and the safety system. The operators manipulate these systems to line-out the process and operate it in a safe manner. Although the plants were nominally 'matched', we can see that even at the level of basic technology, particularly control systems, there were marked differences between the sites.
4. Activities and Time

While the last chapter discussed the technology in the plants, this one discusses the things people did to operate them. It serves two purposes. First, it lays out the four broad categories the people in the plants used to understand time: calendars internal and external to the organization, production supervisors’ tenure, and events. Second, it introduces all the activities I examined at the plants.

The two objectives of the chapter are linked. I assert that people in the plants understood time in different ways, and that those understandings were linked to particular activities. If people were being prospective, they understood time in terms of the calendar, since that contained the activities they could anticipate. If they were being retrospective, however, they understood time in terms of ‘events’ since they were the things that became salient. If they were comparing their current experience to prior experiences, they would refer to events external to the organization.

At the end of the chapter, we will return to the definitions of types of activities we constructed in chapter one (routine tasks, event management tasks) and tie the four types of time into that definition. This will enable us to then tie the data into the literature on technology and organization. In particular, we will be able to reconcile a disagreement in the literature between those who argue that organizational structures are driven, essentially, by the routine aspects of the work (e.g. Mintzberg 1973; Nelson and Winter 1982; Williamson 1986; Goodman 1990), those who emphasize the management of exceptions (e.g. Woodward 1965; Lawrence and Lorsch 1967; Perrow 1967; Thompson 1967; Hickson 1971), and those who claim the relationship between technology and organization is, at least in part, negotiated (Barley 1986; Orlikowski 1988; Barley 1990).

The internal calendar of the plant

A huge portion of the work in the plants was driven by internal rhythms established by management as a result of technical need, convention, law, or corporate edict. Much of this work was routine. That is, people knew when particular activities were needed, how to perform them, and what outcomes to expect. Even shut downs, which were big events for the plants and took a huge amount of work, were fairly routine in their planning and execution. Once someone had done it, they were quite competent to do it again. Embedded within this routine work there were often exceptional events which needed to be managed. For example, within the shutdown planning, people had to deal with a number of novel activities which required special procedures, materials, or design. The first section of this chapter discusses those essentially routine activities that are driven by the plant’s internal clock, arrayed on a continuum of decreasing frequency.

Shifts

Given that the plants took between hours and days to start up and shut down, they had to run continuously. The operators worked around the clock in 12-hour shifts. While some mechanical technicians, known as ‘shift maintenance’, worked the same hours as the operators,
most maintenance occurred during the day on weekdays. Other staff members worked days, though there was talk at Wideplant of moving the engineers to a shift schedule.

For the operators, the shift would begin (and end) about thirty minutes before the scheduled time. At Widesite it would begin and end at 7:30 (scheduled for 8:00), while at Highsite, it would begin and end at 5:30 (scheduled for 6:00). The operators selected these times when the plants went from eight to 12-hour shifts, about ten years earlier. (I was told that the 6:00 change time at Highplant was selected principally so that operators could get to the Friday night high school football game). This two-hour difference in starting time had two important implications for the running of the plants. First, the Highplant engineers and lower-level supervisors with production responsibilities tended to start work much earlier. While they would often be at their desks by 6:00 a.m., those at Wideplant were rarely there before 7:30. Normally, they started only 15 minutes apart. However, both groups tended to finish work between 4:00 and 5:00 in the afternoon with the rest of the day staff. Second, there was much more contact between the day staff and the operating staff at Wideplant. Shift worker who work a 12-hour shift, will work seven days and seven nights in a 28-day period. At Highplant it would take an extraordinary effort for a day staff member to see someone who was working a night shift. They would have to come in more than two hours early (at 5:00 a.m.) or stay back two hours (to 6:00 p.m.). At Wideplant, people could catch up with the group coming off nights by coming in half an hour before normal (at 7:00 a.m.). Effectively, this meant that there were twice as many opportunities for interaction at Wideplant as at Highplant.

The shift schedules through the 28-day cycle also facilitated better communications between the two groups at Wideplant (see figure 2.1). As can be seen from the figure, a given crew at Highplant is only working on weekdays on two weeks of a given month. In one of those weeks, it is only working Friday. Therefore, if a given day-person happens to be off-site on that Friday (a popular day for corporate meetings), she or he will only have contact with that crew on one week of the month. The corresponding Wideplant crew works days in three weeks of the month, so a day person can see three out of four crews in any given week, and all crews in a week and a day (c.f. two weeks). The difference in crew schedules led to one other important advantage at Wideplant. The longest period a Highplant crew worked was four days or nights, while a Wideplant crew worked only three. The four Highplant nights spanned a weekend (when children are home). This meant that the operators had very little sleep and complained of being very tired and bored by the fourth night. For the Wideplant operators, this problem wasn't nearly so severe. However, the Wideplant schedule had two disadvantages. First, the Highplant operators only came to work for four blocks of time in a month, rather than six. This meant they spent less time in transition from days to nights, and back. Not only did the work take up less of their time, as a result, but they were available for more overtime. Second, the Highplant operators had an eight-day break in the cycle. This enabled them to get a lot of rest, go hunting in the Fall, or work a lot of overtime. Notwithstanding, if they took the eight days off, they lost track of what is going on in the plant by the time they returned. For example, one shift supervisor was very surprised to discover during the morning meeting on his first day back that, because of a technical error, the plant had several million pounds of contaminated raw material for process B to deal with

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1 The two sites had dramatically different norms about 'working hard'. At Highsite, long hours were seen as a sign of commitment to the corporation (see also Jackall (1988). Therefore, ambitious staff members put in long hours. At Widesite, long hours were seen as a failure to work 'smart' and were frowned upon. However, working both long and smart, -- i.e. long hours with a lot to show for it -- was seen as a virtue, so long as the person clearly enjoyed the work.
somehow. No one had thought to tell him.

|       | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
| High: | n | n | n |   |   | D | D | D | D | D | D | n | n | n |   |   | D | D | D | D | D | D |
| Wide: | n | n |   | D | D | n | n | n | D | D | D | n | n | D | D | D | D |

Table 4.1 Schedule for a given crew at the two plants.

Days

After shift change at 5:30 a.m., the 'planning and scheduling' meeting for area 'A' at Highplant was at 7:30, while that for areas 'B' and 'C' was at 7:45. Interestingly, the production planning and scheduling operator did not normally go to the planning and scheduling meeting. In fact, in area 'A', the meeting was before he was due to start work and in area 'B-C' it was at the start of the day shift. Instead, the meeting was typically attended by the mechanical planner (a mechanic), the production and maintenance planning and scheduling supervisors, and the supervisors for the various trades. The meeting had a learning and a production component (table 4.2). The learning component was a discussion of the events of the previous day. Items discussed included key meetings, audit results, and conversations, in addition to the maintenance work that actually got done. The production component included discussions of maintenance for the current day and the next day, and maintenance planning. Each day's maintenance was a combination of the work they scheduled the day before (or on Friday) and could get ready on time, emergency work that came up in the preceding 24 hours, and prior jobs which the mechanics didn't get to. The maintenance for the next day came from three sources. First, the computer generated 'ticklers' whenever machinery was due for routine maintenance. Second, machinery which failed its excess vibration test was overhauled. Third, equipment which was playing up was often repaired. Finally, long-range planning normally involved planning for the next routine biannual shutdown.

The mechanics arrived around 7:00, started work at 7:30 and picked up tools at about 8:00, doing the jobs planned at the previous day's planning and scheduling meeting or any emergency work that had come up in the mean time. The rest of the day personnel started work before 7:45. The morning meeting, which is generally attended by about 25 people, was at 8:30. Following this meeting there was often a meeting to manage the pressing issue of the day such as deciding whether to bring down a piece of equipment, telling people about a new initiative, or planning for an emergency shutdown. Most people had lunch at 11:00 and left at 3:45.

Wideplant had no formal planning and scheduling meeting. The relevant people (particularly the planner from operations and the planners from the maintenance and electrical shops) got together informally during the day to determine the next day's maintenance. These jobs were confirmed or modified at the morning meeting on the day they were done. Area 'A' met at 8:40 (about ten people) and areas 'B' and 'C' at 9:20 (about twelve people). Often, though much less often than at Highplant, these meetings were also followed by meetings to address pressing issues. Lunch was also between 11:00 and 12:00 and most day people left at 4:00.
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Table 4.2 Summary of internally-driven activities in the plants

The conduct of morning coffee and lunch was quite different at the two sites. Day people at Wideplant would stop for 20 minutes after the morning meeting and chat. The professionals and supervision would meet in one office while the day staff would have coffee with the operators. More interesting, the maintenance supervisors from across the site had coffee together in the cafeteria. At this meeting, they would allocate mechanics around the site according to equipment demands and absence rates. Apparently, this informal allocation technique had developed spontaneously some years earlier. Lunches differed in that most of
the supervision, administrative staff, and professionals would eat in the Wideplant cafeteria, while they tended to eat in the buildings at Highplant. In part this flowed from the smaller plant size (and therefore proximity), but also from the quality of the food and the atmosphere. The net result was that there was good informal communication across businesses at Widesite.

The morning meetings at the two sites were dramatically different in a number of very important respects. The net effect was that the Highplant meetings were much more routinized in both their conduct and content. I will argue that these differences reflected fundamental differences between the sites and the way they were managed. Therefore, I will leave the comparison to chapter 10.

_Weeks_

Each plant also had a weekly cycle, though it was much more pronounced at Wideplant than at Highplant. At Highsite, the site senior management met on Mondays after lunch to review events for the previous week (learning) and make personnel decisions (production). In the plant, area 'A' would have its weekly safety audit on Mondays and areas 'B' and 'C' would have theirs on Thursday (learning). Safety equipment was supposedly checked every weekend (production). The people in charge of area 'A' would meet weekly to discuss the status and trends of the plant and, every two weeks, the 'powder' business manager would meet with his direct reports, the plant leaders (production and learning).

At Widesite, the senior management would meet at 8:00 on Monday morning to discuss the events of the week (learning). At 10:30, the business managers would have a similar meeting with their reports, and at 11:30, representatives from each business would meet to contribute to the site's weekly newsletter. On Monday afternoons, the supervisory personnel over area 'A' (i.e. coordinator plus facilitators) met for a few hours, while the area 'B-C' supervision met on Wednesday morning (production and learning). These were known as the 'core group' meetings. The business leader would have a strategic meeting with his reports on Wednesday afternoon. Both areas were meant to have their safety audits on Monday or Tuesday and safety equipment was supposedly checked on weekends also.

_Months_

Most plant-level and site-level committees met monthly. At the Highplant 'Site-wide safety health and environment committee' meeting the prior month's safety statistics would be reviewed, new initiatives would be introduced, old initiatives would be monitored, and two or three plant areas would report on their safety programs. The site manager would use this as an opportunity to emphasize those elements of the safety program which he thought were important. This was followed by the site's 'Safety, health, and environment leadership team', which comprised the plant manager, the five or six business managers, and the heads of safety, health, and environment. Policy issues would be resolved here. Other site-level committees that met monthly whose meetings I attended included the 'Process safety management' committee, a committee charged with ensuring the site's compliance with the corporate response to the OSHA process safety management standard, the 'Employee safety awareness committee' which aimed to keep safety salient in employees' minds, and the 'Production and maintenance plant leaders' meeting'.

At the plant level, there was a monthly safety meeting for the day staff. The topics of meetings I attended included 'killer bees', 'locking and tagging', 'latch-key children', and 'ergonomics' (learning). These were organized by the 'Plant Safety Committee' which was the plant-equivalent of the site Employee Safety Awareness committee. Each shift had a safety
meeting on Monday night before it started work (one meeting per month for each crew). This was generally work-related and was run by the shift supervisor. The ‘Plant Improvement Team’ also met monthly to monitor the ‘continuous improvement process’.

Wideplant also had a monthly site-level safety meeting. However, this was much more like the Highplant safety, health, and environment leadership team meeting. It involved just the business leaders, the site leadership, and the heads of the health, safety, and environment functions (learning and production). In addition, there was a meeting of the labor-management ‘Joint Health and Safety Committee’ (production). About a week prior, the union conducted two all-day safety audits of different sections of the plant (learning). At the plant level, there were monthly meetings of the Area ‘A’ change initiative team (see chapter 18), and both areas’ safety and environmental teams (both). Area ‘A’ had monthly safety meetings, and Areas ‘B’ and ‘C’ had monthly meetings between area management and the crews.

Every three to six months, the Highplant business manager would have a meeting with all the area supervision. Other than at hand-over between shifts, this was the only time the various shift supervisors saw each other.

**Downtime/uptime**

In the two annual shut downs, the plants would overhaul or replace equipment, tie in or install process modifications, test interlocks, and install control equipment. All this would have to happen in a five to 15-day period (although process ‘A’ at Highplant was down for six weeks to install the DCS). These shutdowns would be preceded by months of planning which dictated peoples’ work. Not only did people design and fabricate modifications, but they also determined their safety, scheduled labor, hired contractors, and wrote procedures for novel tasks. Furthermore, they scheduled all the jobs within the shutdown so they were done in the right order using the right amount of labor. All of these were production activities.

The shutdown, and its planning, increased the contact between the plant and the central maintenance shops, central stores for the site, the construction group and external contractors. Central maintenance overhauled all the valves and smaller equipment which were brought out of service in the shutdown. Central stores coordinated the provision of spare parts. The site construction group provided a lot of labor. Contractors provided extra labor and specialty services such as hydro-blasting of vessels or overhauling of complex equipment.

As noted above, many shutdown activities were routine, but some were novel. In addition, shutdown times tended to be unpredictable. Since the corporation had to maintain a world-wide inventory of ‘compound’, shutdown timing was always contingent on the performance of the fleet of plants. Similarly, major mechanical problems would force shutdowns of large parts of the plant. Given a couple of days’ notice, this would create a window for performing maintenance that would normally be included in the next routine shutdown.

**Years**

Every year, supervisors and engineers (but not operators or mechanics) at both plants had their performance reviewed (learning and production). One fifth of each plant would have its quinquennial ‘Cyclical Process Hazards Analysis’, a rigorous analysis of all the possible failure modes of the plant to ensure that it was protected adequately. All equipment (including ladders, chairs, and hoses) would be checked for safe operation once a year. Interlocks would be tested every couple of years.
Examing routine activities

A cursory examination of Table 4.2 indicates that the internally driven activities at the plants are nominally fairly similar. This is particularly true when we consider that the vast majority of the work is routine production and maintenance. However, there are some differences that are worth noting. The first is that people tended to work on a much shorter time-scale at Wideplant. In particular, all the relevant management groups met among themselves and with their supervision on a weekly basis. At Highplant, management didn't think this was needed and so the equivalent activities tended to be less frequent. In contrast, Highplant had more meetings directed at particular technical problems, such as those of the continuous improvement team, or the production trends meeting. Finally, at Highplant, there were more activities which operated at a higher hierarchical level and on a longer time scale. Again, these tended to be relatively specialized meetings.

On average, this probably means that people spent about the same amount of time in meetings, discussing the same things at about the same frequency. However, instead of going to four specialist meetings a month, as they might at Highplant, Wideplant employees would go to four more general ones where the same issues were discussed. However, if the same activities were carried out, does that mean there were no differences between the sites? We will see in chapters 10 and 11 that the important differences lay not in the activities conducted, but in the way they were conducted.

The external calendar and its impact on the plant

By definition, external stimuli are those the organization cannot control at the source, and therefore must respond to. Many of these stimuli were periodic. The corporate capital budgeting cycle, for example, drove a lot of activity in the plants. This was particularly true at Highplant, which had a much larger capital budget. Capital requests had to be made by a certain date, and were accompanied by 'Reason sheets' to justify the expenditure. Over a period of months they would climb up the hierarchy and get funded (or not). The money would then have to be spent by certain dates. The plants had little trouble slotting some of these -- such as the corporate accounting or capital budgeting cycles -- into their routines.

However, with others they had much more difficulty, and so the environment's incursions into the organization would create events. Therefore, it is not surprising that people would often measure time in terms of these external events. So, the arrival of the Summer students was seen as a time of greater safety risk, the Winter was a time when people had to work harder, October was when the projects had to be in, and so forth. In this section, I will consider the weather and the way it interacted with the accounting cycle.

The time of year had opposite effects at the two plants. At Highplant, the Summer was the season of note. Simply, it was very hot, particularly for people wearing flame-proof clothing, and so the work slowed down. At Wideplant, the Winter was problematic. There were three reasons for this. First, it was much harder to unload raw materials in the Winter because they arrived on site frozen. Therefore, unloading, which took about an hour, had to be preceded by steaming, which took two or three. Furthermore, cars could only be unloaded in daylight hours. As a result, if all the shunting went smoothly (which it rarely did), only two sets of cars could be unloaded daily. (When running at maximum rates, the plant consumed about 70% of this daily maximum). Second, it was also much harder to transport rail cars to and from the site. A big snow storm anywhere on the continent was likely to delay the trains (empty or full) for a day or two. Third, the corporate accounting year ended in December, and so they would run down all of their inventories for the new year. In addition, demand was always
very uncertain in January (presumably because customers were also trying to keep inventories down all the way along the value chain). Therefore, they would start the new year with low amounts of raw materials on order. Either bad weather or a step increase in demand would throw the whole system into chaos. During both my Winters at the plant there were huge fluctuations in the amount of raw materials available. They would have a very low inventory, and the amount of materials sitting in trains on the site would swing wildly between running out within hours and overfilling the shunting yard. (For an elaboration of the dynamics of such a system, see Sterman (1989)).

Second, ice was a major problem. The plant was cold enough that any steam leaks or vented steam would freeze. Within a day or two the smallest steam leak could grow into an icicle large enough to severely damage equipment if it fell. During my first Winter at the site, a 200-pound icicle formed on a new piece of equipment which was poorly designed. It fell through the roof of one of the maintenance shops (which had been evacuated as a precaution). The second Winter, someone installed temporary steam tracing in a hurry and allowed it to vent to the atmosphere (instead of returning the steam to a condensate line). Within two days, the icicle was six stories high. Operators would dissolve the icicles with steam hoses. However, the steam would condense in puddles that would turn the floors of the buildings into ice rinks.

Finally, the processes didn't like the cold. Not only did they become harder to run, but if they stopped, the equipment would cool rapidly and be hard to start up again. Similarly, any failure in the steam tracing would often lead to pipes that froze and burst. On some systems, the leak wouldn't become apparent until the pipe thawed. Therefore, any shut-down was always a concern and major shutdowns in the winter were very problematic. Parts of process 'A' and 'B' and all of process 'C' took place in heated buildings.

Plant leaders’ tenure

The third way in which people understood time, particularly at Highplant, was in terms of the tenure of a particular production supervisor. For various reasons (discussed in chapter 6), the Highplant production supervisor (called the plant production leader) was extremely powerful. His or her attitudes and stance towards various problems had a huge impact on the way people behaved and interacted, as well as on outcomes in the plant. Therefore, people would almost always partition history with reference to the production leader at the time they were talking about.

When people talked in terms of these external cycles, or in terms of the boss’s tenure, the discussion was always relative. The way we are dealing with the snow this year would be compared, explicitly or implicitly, with last year or some particular time in the past. Similarly, the strengths and weaknesses of a particular plant leader would always be cast in terms of the one before, or the one before that.

Non-routine events

The final way people understood time was in terms of events. In chapter one we defined an event as any activity in which the sense making, problem-solving, or implementation contains an element of “surprise”. If surprise is what defines an event, we would expect the event to begin with a rapid increase in activity focused on a particular stimulus and to end when the stimulus goes away or is redefined. If I asked someone for an example of something, they would always tell me about an event, such as "the time one operator burned his face by putting
his head inside a piece of machinery", or "the time the dryer stopped because it was over-
loaded", or "the time they nearly blew up process 'A' because someone had changed the scale
multiplier on one of the meters". Similarly, the morning meeting is often a set of descriptions of
events: "The dryer went down last night" or "We intend to defrost a crystallizer tomorrow".
People tended to construct the history of the plant in terms of events.

Events come in two varieties, 'reactive' and 'proactive'. Reactive events occurred when
the environment successfully penetrated the organization (e.g. a plant being hit by lightning, a
surprise visit by the regulators, the community oversight committee demanding that a smell be
eliminated, or Greenpeace climbing the water tower), or when there was a failure in the socio-
technical system (a pump breaks down, someone trips and falls, an alarm goes off). Reactive
events are associated with alarms ringing, equipment stopping, tanks overflowing, people
going hurt, and unplanned shutdowns.

Proactive events are precipitated by people anticipating failures in the system or
redefining the system so that current practice is seen as a failure. That is, they are heedful
(Weick and Roberts 1993). Proactive events differ from routine happenings in that they are
generated by a process of feeding forward and anticipating possibilities. For example, it is a
proactive event if someone works out how to maintain some equipment for the first time. There
is an element of the unknown, creativity, or innovation which is not present in routine
happenings.

Just as people must actively anticipate the failure of some aspect of the socio-technical
system to initiate a proactive event, so they must experience surprise to initiate a reactive
event. Whether a particular stimulus leads to a surprise will depend on the skills they have to
manage it and stimuli they expect. That is, the events are not objective; they are enacted
(Weick 1979). In this dissertation I will adopt the convention of referring to an unexpected
stimulus as an 'exception', and an exception which is enacted as special as an 'event'. Once they
choose to react, people must decide how to do so. Their reaction is often a function of the label
they give to the event. Different labels initiate different responses or organizational routines
(Nelson and Winter 1982). Therefore, in this study, we will examine both the way events are
enacted and the way they are managed once the enactment has occurred.

Making sense of four views of time

In this chapter we have seen four different ways of understanding time. When people
looked forward, they thought in terms of the calendar; when people thought in relative terms
they talked about incursions from the environment or boss's tenure; when people looked back,
they talked in terms of events.

There was a logic to this, and it relates to the way the people constructed the
production process in their minds. First, we can see why people will use the calendar to project
time forward. That is the only thing that is certain. However, that understanding was
relatively weak in the face of competition from events. Routine activities would often be
canceled if something else came up. This was particularly true if the routine activity was
contained within an administrative group rather than involving people across groups. Not
surprisingly, routine activities that were not fun and hard to monitor would also tend to
disappear, particularly at Wideplant (where there was less monitoring). So, for example,
safety audits and routine equipment inspections had a habit of not happening because
something else had come up (cf. Alchian and Demsetz 1972).
To understand the use of 'events' for retrospective understanding, the reader should consider two things. First, realize that people saw their task as one of 'lining out' the system. That is, controlling its behavior so it was completely predictable. At both sites, they would frequently tell me that the best possible thing would be for them to be sitting around the control room, bored, because that was when they were really making money for Transitech. Given this, and the second fact that 'surprises' tend to be associated with arousal, we can see why they would frame their understanding of the work in terms of deviations from this desired state of smooth operations.

There are, of course, alternative constructions. These, in turn, lead to different constructions of events and their importance as partitioners of time. For example, under a 'continuous improvement' framework, events might be desirable because that means you are pushing the edge of the technological envelope. If the events are expected and desirable, they are less likely to be salient markers of time. Alternatively, a focus on maintainability (Carroll, Sterner et al. 1995) would lead you to routinize many proactive events. Only adverse events would be significant markers. However, if you have a construction which sees all events as bad, and events tend to be marked by arousal (i.e. surprises), it is no surprise they should mark history.

The marking of relative time by such things as the boss's tenure or the weather appears to come from the over-arching schema introduced in chapter 1, that management shapes organizational outcomes:

![Diagram](image)

**Figure 4.1. A representation of the over-arching idea that organizational outcomes are achieved by the act of "management" applied to the organization.**

In particular, implicit in this schema was a 'playing field' on which such management occurred. A new boss was powerful, and therefore brought new expectations, new resources, and new limitations on behavior. Similarly, the changing weather determined how hard the job was. I expect that people would describe any change in constraints the same way. In fact, although they didn't use time nearly as explicitly, they would make qualitatively similar statements about the old production system, or the old control system, as they made about the old boss.²

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2 One uncontrollable methodological issue in this dissertation is the extent to which the findings are a reflection of the attitudes and styles of the production supervisors in the two plants rather than in the rest of the organizations. However, since the supervisors were selected with the site's management strategy in mind, this is probably not a problem.

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A *foray into the literature*

What does this analysis tell us about the literature on technology and organization?
As I noted in the introduction, that literature can be divided into essentially three streams. One group of authors -- the contingency theorists -- talks about the importance of uncertainty and unexpected events in the determination of structure. A second group -- the technological determinists would counter, instead, that the technology itself is the important thing. A third group -- the structurationists -- would say that both are wrong, and that the technology merely provides a forum for the structure to be established.

From the analysis presented here, we can see that it is possible to reconcile all three positions, since they are talking about different aspects of the work. For routine operations, which take up the vast majority of the time in a plant, the technology is the major determinant of the way work is done, alongside other fixed artifacts such as laws and rules. Anyone who took a time-averaged look at the way work is done would conclude that Goodman and his friends are right: Most work is routine and since the routine work is tightly coupled to the technology, it is predominantly determined by the technology. On the other hand, productivity is determined by the organization's ability to avoid exceptions and manage them once they occur. In part, these are prevented through routine operations (hence the technological determinism). However, Perrow and his followers were right to highlight the importance of response. They were wrong in assuming that the work organization for routine operations should be the same as that for managing these exceptions (see also Roberts (1993)). There are many other possibilities. Finally, both routine operations and exception management occur on a playing field which is determined in part, but not fully, by such things as the technology and the law. The structurationists provide insight into the way these things get turned from possibilities into a playing field.
5. Organizational histories, technologies, strategies, and environments as determinants of structure and action

As we saw in chapter 1, the organizations had to perform four classes of tasks: routine production, event management production, routine learning, and event management learning. We expect the way the organizations carry these tasks out to be a function of their technology (Woodward 1965; Perrow 1967; Thompson 1967), their history (Schein 1985), their strategy (Chandler 1962), and their institutional environment (Pfeffer and Salancik 1978). We saw in chapter 3 that the organizations had virtually identical technology. We will see in this chapter that, in the main, the organizations have equivalent external environments. Their histories were equivalent until about 1980, after which they diverge when management at both sites changed its human resources strategies.

History and technology as determinants of work organization

This section summarizes the management of the four major classes of tasks (routine and event management production and learning) in the two plants prior to 1980. These four tasks are inherently contradictory. One central contradiction is that between controlling operators and using them for learning purposes. If their behavior is controlled, they are less likely to do "stupid things" that lead to process upsets, up to the limit of the organization's understanding of its technology. The intuitive way to achieve this is to make them virtually part of the machinery. That is, routinize as much of the work as possible, forbid them from doing anything other than what they are told, and punish them severely if they disobey. However, this is likely to diminish their skills, their enthusiasm and their initiative, and therefore their desire and ability to manage exceptions. It will also give them an incentive to not report untoward events. In other words, exceptions will be managed poorly and learning opportunities will not be discovered. Therefore, the structuring of the operating work can be understood in terms of conflicts between controlling the operators' behavior, giving them the freedom to manage events in such a way that they can build their skills, and giving them the freedom to bring forward untoward events so that learning (and hence innovation) can occur.

For all intents and purposes, these four functions were managed in the same way in the two plants up to about 1980. The plants used two devices to reconcile the contradictions. They separated learning from production by designating learning as an engineering function while production was carried out by the production and maintenance organization. In addition, their dominant strategy for the management of exceptions was to exert as much control over the organization as possible.¹

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¹ In other words, the traditional production organization was fairly “Fordist” in design. However, this did not derive from specialization through the division of labor (Sabel 1982), but rather out of a need for control over the technical process (Edwards 1979).
Routine production

A huge part of the work which goes on in a chemical plant is routine and is linked closely to predictable pieces of machinery, actors in the institutional environment, or events through time. As such, certain pieces of work need to be done and, in the narrow sense, it doesn't matter much who does them. Samples get taken, machines get started, pumps get overhauled, trains get loaded, costs get accounted for, capital moneys get applied for, materials get ordered, people take vacations and others take their place, and so on. Williamson (1986) argues that organizations will structure these activities to minimize total costs. We will see throughout the dissertation, however, that it is never quite clear what constitutes "total". Every activity has the potential to provide training (or boredom) to the agent involved, so there is an opportunity cost associated with getting someone who can do a job easily to do the job.²

Given that labor constituted only about 10% of cost, and upsets cost a small fortune, it is not surprising that the management of exceptions traditionally dominated organizational design. Two strategies were pursued to do this. The first was to routinize as much as possible through procedures which made the operators virtual extensions of the machines. Second, foremen were used to ensure compliance with procedures and to tell people what to do when the procedures were inadequate or contradictory. They achieved this by exerting a tremendous amount of direct and coercive control over the production operators. The operators talked of "checking their brains at the gate". They would do nothing unless told to do so by a supervisor. They would then do precisely what they were told, irrespective of whether they knew it was a poor decision.³ Notwithstanding, because the automatic control systems were much poorer, the crews were much larger. Therefore, people were expected to exhibit reasonably high levels of skill in the execution of each job. In return, the supervisors were fully accountable for anything that happened on the shift.

Within Transitech, that accountability continued up the line, particularly for accidents, fires, explosions, and other safety events. Foremen would be disciplined severely by second line supervisors, who would be disciplined by the plant leaders, and so on. A serious accident or workplace death would often leave several layers of supervision, often including the site manager, without jobs (for those low down) or salvageable careers (for those higher up). Remnants of that culture still remain.

There are a number of reasons why managers might have emphasized control over the system at the expense of both capacity to manage exceptions and ability to learn from them. First, as Stinchcombe (1965) noted, organizational forms tend to reflect the period in which the organization was founded. The organization continues to function effectively, so there is no need to change and its form becomes institutionalized as various actors develop interests to keep it in place. The U.S. chemical industry has its direct roots in Du Pont and the explosives industry (Chandler 1962) which, in turn, has its roots in the military. The British chemical industry was led by Nobel, who invented dynamite, and the German chemical industry began with dye manufacturing for the military leading up to the First World War. Furthermore, the industry

² Therefore, Williamson's theory is untestable. The organization's minimum cost is an aggregated utility function for efficiency, learning, and boredom. The method of aggregation is necessarily arbitrary.

³ As we will see, some supervisors at Highplant still demanded this sort of obedience at the time of the study, though the operators felt free to question a decision before implementing it anyway.
grew tremendously during the two world wars, especially the second, when plants were run as military installations. Given the high risks in explosives manufacture and the strong links to the military, it is no surprise that the industry was traditionally managed with the discipline of a 19th century army.

Second, there was a technological imperative. Chemicals processing is traditionally a very risky business, with plants containing vessels full of highly flammable, toxic, or corrosive materials at high temperatures and pressures. Furthermore, it is extremely easy to liberate these materials. Plants can readily blow up or cover people with deadly materials, especially if behavior is not well controlled.

To understand why this might be, we should consider part of the central argument of Perrow's *Normal Accidents* (1984). Perrow argues that accidents occur as the result of the simultaneous failure of two or more sub-systems which were thought to be independent. He goes on to define systems accidents as involving simultaneous failure of two reasonably large technological sub-systems. He exemplifies this with common-mode failures, one of many forms of interdependence. In this sort of accident, the two sub-systems are linked by one piece of equipment being a member of both sub-systems. For example, a heat exchanger might provide heat to one sub-system and cooling to the other. A failure of the heat exchanger would cause one sub-system to heat up and the other to cool. Simultaneous failure of both systems could lead to an uncontrollable situation.

Perrow estimates that about 10% of major accidents are systems accidents. At first blush, this number appears extremely high. Obvious common-mode failures, such as the heat exchanger example, don't fit his requirement that the systems be thought to be independent. They are clearly inter-dependent, so the accidents are probably anticipated and designed against. If the failures are not common mode, then, Perrow has us imagining two pieces of equipment failing at the same time. However, for independent or quasi-independent failures to be simultaneous, the failure rates of the individual sub-systems need to be inordinately high. In fact, I would guess that they would need to be so high that it would be impossible to run the plant at all.

What Perrow fails to emphasize, yet illustrates in his description of the Three Mile Island accident, is that all but one of the requisite failures has generally occurred before the accident. That is, a lot of the contributing causes tend to be the result of poor maintenance, not getting broken things fixed, and not attending to known errors and faults. When the final failure occurs, it erupts into a situation in which all the various sub-systems have concurrently failed, though they may have failed months before (see also, Reason 1990). If this is the case, then safety can be enhanced by ensuring that all of the various technological and interpersonal components of the organization are behaving as designed. In such a situation, safety can be enhanced by controlling people's behavior to ensure that things are not allowed to become sloppy.

Third, and strongly related, there may be a legal imperative. Management has a duty of care to protect the workers and that duty can most easily be satisfied if management doesn't ask the workers to think, but instead, thinks for them.

Fourth, and finally, we can combine the work of Hirschhorn (1988), who suggests that managers may have a psychological need to believe they are in control of the things for which they are accountable, if that accountability makes them anxious, with that of Argyris (1990) who suggests that the intuitive way to "be in control" of a situation is to explicitly direct others. (The counter-intuitive strategy is to ensure others have skills.) For a number of important cognitive and emotional reasons, we can expect people to behave in the intuitive way (Argyris 1990; Cebon 1991), especially under strong pressure from their broader institutional
environment which specifies both the desired outcomes and the way they should be achieved. As the pressure to produce those outcomes increases, we expect a threat-rigidity effect (Staw, Sandelands et al. 1981) which increases the tendency still further.

Other strategies for avoiding events

There were two other ways, other than through direct control, in which exceptional events were avoided. First, the technical system was made more robust through redundancy and buffers. For every pump, there was a standby. For all equipment, there were vast stores of spare parts. Second, exceptions were avoided through preventative maintenance. Equipment was maintained much better than in the 1980's, and people at both sites bemoaned the depletion of skills in the maintenance shops. Apparently, in the past, they had many more, and more highly skilled, mechanics to do the corrective and preventative maintenance. In addition to the organizational changes which may have induced the change, it is worth recognizing that the need for maintenance was much less than in the past. Both the equipment and the control systems are much better today and there was a lot less of it. There is less equipment because the philosophy of design has changed. Instead of having six process units operating in parallel for a given function, people now tend to use one very large one. With six, five could be in service while one was being repaired. The problem was that one was always being repaired.

Managing events

Exceptions had to be managed if they became large enough to be events. Perrow (1967) argued that organizations could be categorized in terms of the exceptions they manage. His typology had two dimensions, the number of exceptions that the organization had to manage and their analyzability. While the theory has some logical problems (See Cebon 1991), it encourages us to think about organizational structure in terms of the problems that can be solved by an individual, the problems which can be solved within a work group, and the problems which spill over between work groups. In chemical plant operations, we expect to see a huge number of very small exceptions and decreasing numbers of larger and larger ones.

The huge number of small exceptions tend to be unanalyzable a priori because they are extremely dependent on both their physical and temporal context. Furthermore, careless operators and mechanics can easily get hurt when trying to manage exceptions. This is, of course, irrespective of whether management believes that operators are just extensions of the foreman's hands. Therefore, Perrow would predict that operators and mechanics would be craftsman-like in their training and behavior. This is what we see. At both plants, operators always went through long training periods before being promoted to full pay (though they used to be much shorter periods in the past) and, until a few years before the study, the mechanical trades (mechanics, electricians, etc.) had to qualify initially as operators.

At this point, it is worth noting a contradiction generated by the traditional work design. On the one hand, the training required relatively bright operators and mechanics who were capable of learning. A chemical plant is a very complicated place and stupid or untrained people can hurt themselves or others very easily. Over and over again, Wideplant controllers told me that the five years of formal training was just a start, and that one of the problems with the job rotations was that they feared losing their skills. On the other hand, once the operators had learnt their job under the traditional organization, there was nothing more to learn. Management, through the control system, circumscribed the work rigidly. Therefore we can guarantee that this system of work organization left people bored.
If exceptions spilled beyond an individual, the supervisor would manage them and determine what to do. Presumably, a good supervisor would also get help from his or her operators. If equipment broke down, he would turn to the large shop of highly skilled mechanics. If he wasn't sure what was going on, he would bring in some engineering assistance. That is, the site organization was dominated by three functions: operations, maintenance, and engineering. They constituted the core of the organization and had high reciprocal interdependence (Thompson 1967). They would solve the problems and then the appropriate group would execute the solutions. If the problem were still too difficult, site management would bring in technical assistance from corporate engineering.

Of these three functions, engineering was the most powerful. This appears to follow from the fact that, until the early 1970's, Transitech was a monopolist in most of its markets. Therefore, its ability to make money was determined by its ability to manufacture. To manufacture it needed new plants and engineers who could run the existing ones. As such, the corporate engineering organization was tremendously powerful (Hickson 1971), and so engineering dominated manufacturing which, in turn, dominated the businesses. On the site, the engineers used to dominate the production organization also. Operators at Widesite told me of the times in the 1970's where the panel operator could hardly see the control panel first thing in the morning because the engineer for each section of the plant -- there were about 12 instead of the current four -- was down telling them how to tweak that section of the panel. Presumably, Highsite was similar.

In addition to these core functions, there were many groups providing inputs and disposing of outputs for the manufacturing groups (Thompson 1967). These included a personnel group, a safety group, materials acquisition, shipping and receiving, a medical group, construction services, and a waste treatment plant.

**Exceptional and routine learning**

Finally, we turn to learning. Until the early 1980's this was relatively straightforward. First, most learning did not occur in the production areas, but rather came down from the research labs or the corporate engineering department. So, identification of a hazard or a strategic opportunity might spawn a new way of running part of the process. Learning in the plants was generally around production and safety. Learning about the production process was principally the task of the production engineers. Learning about safety had a dual purpose: to find out what was wrong and to assign blame appropriately. If something went wrong, there was a good chance that those who were proximate would be punished. As one retiree who reviewed an early version of chapter 17 put it:

Politics have always been a primary force in the investigations but less so in ... times where the organization I was in had strong leaders who espoused a philosophy of safety and had some framework for thinking about it. Other times the politics got much stronger when we tended not to have a philosophy in the organization, but focused more on the rules and adhering to the rules. In this case, sense did not count for much as long as we had someone to blame who did not have the power to resist.

... In times where we were growing the business and were experimenting with new processes, we were more interested in the facts and discovering what actually happened. Ignoring the facts could lead to major safety and business problems. This was very clear when I worked in (a business) which had a history of explosions. People were not interested at all in who was to blame for
safety problems. They were focused on avoiding being blown up themselves and therefore facts were precious. On the other hand, when we were expanding the (process B3 area of 'compound' production), which had very little strategic impact, we were much more sloppy in pursuing the facts. This was because (the corporate manager) wanted the process to work for his own reasons and people were reluctant to find facts which killed his pet business. (e-mail 931115)

Strategy as a determinant of work organization

Having considered the historical starting point, we now consider the evolution of human resources strategies up to and including the time of the study. Through the 1970's and early 1980's both sites felt pressure to restructure their work organizations. Cost became a much more important consideration since profits had fallen along with market share. High energy prices, inflation, and a high U.S. dollar brought this to a head in the early 1980's. At the same time, technological changes reduced the need for labor, and hence supervision. The engineers managed to design out a lot of the operating problems and improve the control technology so that the plants were much easier to run. That is, the technology became much more linear (Perrow 1984). In the meantime, the Japanese were usurping the U.S. automobile industry and using dramatically different forms of work organization to do so. This created mimetic pressures (DiMaggio and Powell 1983) to change the way the company managed the relationship between the four tasks (routine and exceptional production and learning).

The corporation's first response was a program in 1982 called "Organizational effectiveness" (OE). It had four work-place objectives:

* "extend the quality of thought, mode of behavior, and level of energy applied to work,

* "increase the quality of integrated thought,

* "increase the willingness and capability to identify, develop, and implement changes, and

* "increase thought and action that will continually extend performance." (American productivity center 1987)

In slightly less jargony terms, the corporation wanted to reduce the separation between engineering and production, increase the emphasis on innovation (and therefore learning from the process) relative to ongoing production, and tap into the operating personnel as a resource base.

The plants approached the implementation differently. I will argue in chapter 11 that these differences reflected a fundamentally different type of rationality which pervaded the sites. Highplant's rationality was essentially "formal", while Wideplant's was essentially "practical". In this chapter, I will simply describe the implementation and subsequent changes through the 1980's, in so far as is needed to understand the plants' strategies at the time of the study.

The reader should realize that four factors complicated my ability to get a "true" picture of the current strategy. First, there was no consensus. Second, I was trying to describe a
moving target. At all levels in the corporation, people were constantly reconstructing their theories of the desired and desirable changes. Third, these sorts of objectives were never clear. While we will discuss the importance of this lack of clarity later (chapter 16), the important thing to note is that no one can ever say exactly what is wanted. Finally, corporate discourse contains so much jargon that it is virtually unintelligible to an outsider. For example, one document I read contained the following principle (among five pages of similarly unintelligible and ambiguous principles) for the management of the site:

"We will remove barriers created by roles and stove piping and operate on a more self-to-self basis."

Corporate designers are included among those who constantly reconstruct their theories of the organization. With each new design comes a new vocabulary. The corporation was strewn with terms describing very similar things. As one European manager protested after a presentation at a U.S. meeting I attended, "Six months ago I went back and told my people all about 'clouds'. Now, I must tell them that clouds are out, and that in future we talk about 'bananas' and 'cucumbers'."  

Highplant in the 1980s

Highplant implemented a new program every two or three years in an attempt to increase productivity. The "organizational effectiveness" program was followed by programs for quality and continuous improvement, then an experiment in with self-managed teams based on the Wideplant organization, and finally a certification drive under the ISO-9000 standards. None of these was terribly effective at improving productivity, and so improvements tended to come from changes designed by the engineers. However, these programs had two effects that impacted on the site. The first was that long-term employees at all levels became extremely cynical about various attempts at organizational change. The second was that safety standards and performance eroded.

Highplant: strategy at the time of the study

At the time of the study, two contradictory organizational change objectives were in force at Highplant. In addition, a number of clear lessons that had come from the OE experiment were being applied. Particularly, management decided that people could not be given complete freedom, but had to be constrained and directed by management.

The first organizational thrust was in the direction of safety. By the early 1990's,

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4 It may well be possible for me to sit down with the various documents and the literature to construct a coherent statement of what they were trying to do. I have tried to do that as much as practicable. However, absolute clarity is irrelevant to one of the main points of the thesis. People in the organization are not expected to become experts in organizational theory so they can interpret the jargon coming down from the corporation. Furthermore, at many plants, it is more important that they understand their boss's interpretation of the jargon than the corporate intent. So, although I have tried to be as clear as possible, the reader should be aware that people were never really sure what was wanted.
safety performance had declined considerably. Interviewees told me how they feared coming to work at that time, whereas they never had in the previous 20 years. The current site manager -- who had an excellent reputation throughout the corporation for building effective safety programs -- was appointed, in part, to reverse this trend. He re-centralized safety management, enlarged the central safety office to four young people (instead of two who were approaching retirement), and re-emphasized the traditional approach to safety management by threatening the jobs of anyone who behaved irresponsibly and punishing their supervisors with reductions in pay.

The second thrust was in the area of workplace reform. Here, however, the message was mixed. On the one hand, management had attempted to implement the Wideplant system and it had failed. Therefore, managers told me that they were not going to try again. On the other hand, the continuing success of Wideplant, with its lower staffing levels, older technology, and higher performance, was becoming embarrassing. Senior business managers and people from other businesses on Highsite were visiting Widesite and coming back with glowing reports. The plant was presumably under pressure to implement the new system. Just before the end of the field work, as a result of a corporate re-engineering, high level responsibility for the 'compound' business changed, and it appeared that the pressure was going to increase even further. Notwithstanding, at the time of the study, that pressure was being resisted.

Rewards for good performance and the rhetoric of safety.

Finally, as a residual of the "continuous improvement" program, and possibly as an extension of the local individualistic culture, Highplant tried to encourage innovation through the use of individual incentives. In particular, management gave cash rewards for good suggestions and behaviors. For reasons we'll discuss in chapter 10, the operators did not think much of these.

Not surprisingly, the site's safety rhetoric was highly individualistic in its framing also. In a conversation, the Highsite manager said to me, "Safety was a condition of employment here. That means, if you screw up, I'll sack you. But, we have to talk about what screwing up means." Similarly, the site safety manager had an 8.5" x 11" sign on his door reading: "Safety is a condition of employment." Throughout my visits, safety was always cast in terms of, or in opposition to, individual managers, engineers, mechanics, or operators. I will illustrate this clearly in chapter 17. Parenthetically, until Bill's case (also in chapter 17) no one at Highsite had ever been sacked for a safety violation, though many people had been punished.

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5 With the exception of these years, Highplant had one of the best safety records in Transitech.

6 This was done by changing the supervisors' relative rankings compared to their colleagues. The peer ranking determines the rate of salary increase and promotion. Once in a given relative position, it takes a long time for someone to change it significantly, since a move up requires someone else to move down. Therefore, a reduced peer ranking through an accident can be very expensive for a long time.
Wideplant in the 1980s.

The Wideplant story is quite different. Relationships thawed slowly from the strike until about 1979. From then to 1982, Widesite eliminated 8 of 13 layers of hierarchy. Then, in 1984 and 1986, they started up two new processes based on the strategy outlined below. One was very successful, while the other was less so and operated with supervisors on shift for several years in the late 1980's. In 1986, Wideplant lost exactly half its market to a radical new technology developed by the corporate organization. They cut the number of operators (without a layoff), and then obtained funds for an expansion which would recreate the market. In the late 1980's management committed itself to retrofitting the new organization with a model based on the startup plants.

Wideplant: strategy at the time of the study

Two objectives were driving the Wideplant change strategy. The first was a critique of the traditional approach to the division of labor. The second was a recognition of an incompatibility between the rigidity of a traditional organization and the flexibility required because of the variation in the work load induced by exceptions.

As we saw in chapter 3, chemical production is a sequence of steps along a value chain starting with raw materials and ending with satisfied customers and (possibly) packaging materials being returned for reuse or products being returned for recycling. Widesite management believed that one of the major problems with the traditional organization was the way it performed these tasks, namely through a minute division of labor. People who knew only how to perform one task would be unable to see the business as a whole. This failure to see the business as a whole would lead to five classes of problems.

First, locally rational decisions could be globally highly irrational. For example pushing a problem onto the next shift benefits the individual operator. However, the delay would probably make the problem worse, and the behavior itself would be an exception to be managed because it would create conflict between the crews and an incentive for the other crews to do the same back. Therefore, a control infrastructure had to be put in place to ensure that people didn't cheat 'the system', and to mediate the fights between groups as these interests were resolved.

Second, given their very narrow perspective, people wouldn't take any responsibility for larger outcomes. Management described this as a "lack of accountability" in the organization. People would tend to be much more interested in assigning blame for problems than in fixing them.

Third, if everyone had a highly circumscribed role, the inputs and outputs to that role, and therefore the interfaces between jobs, had to be clearly defined. In order to create that definition, the organization had to construct a large superstructure of procedures, best operating parameters, and the like. Not only did this entail a lot of work in both their construction and execution, but it made the organization very inflexible. Furthermore, it required a superstructure to mediate disputes between the parts.

Fourth, they made insightful observations which are consistent with attribution theory (Nisbett and Ross 1980). They noted that a huge amount of conflict in the organization came from "the old blaming game". That is, when something went wrong, people would blame another group in the organization. To a large extend, this blaming came from an attribution error. That is, people underestimated the problems faced by, and over-estimated the
capacities of, other groups in the organization. When things went wrong, they assumed that
the shortcomings which could be ascribed to the other group should be ascribed to the other
group, whom they believed to have malicious intent. That is, they made the fundamental
attribution error.

Finally, management believed individuals in such an environment were bored. First, as
noted above, the learning stopped after about five or ten years. Second, the nature of the
process -- particularly its variation of workload with events -- led to operators with a lot of
spare time on their hands. This leads us to the second critique.

The second critique comes from the incompatibility between the technical process and
traditional work organizations. As we noted above, a significant portion of the work involves
the management of events, varying from small exceptions to major calamities. If the plant is
running well, which is the case, hopefully, most of the time, the operators are sitting around
doing nothing. If, alternatively, things are going badly, the demand for labor far exceeds the
supply. This leads to two problems. First, if the operators are doing nothing, the company is
paying very high wages for no work. Second, if the operators are bored, the shift drags and
morale sags.

Aims for a new work organization.

The aims of the new work organization, then, are first to get people acting as if they
understood the 'total business' and cared about it, and second to have them working
productively the whole time.

To know the business, you need teams

However, there are two problems. First, the 'business' is multi-dimensional. There are
many interfaces between a given production operator's job and the rest of the operation. Most
obviously, there is the link between one operator's job and other jobs within the production unit.
Then, there is the link along the value chain from raw materials through to the customer. In
addition, there is a link from operations to other functions in the plant such as maintenance,
instrumentation, electrical, the laboratory, engineering, digital control systems, mechanical
vibrations, metallurgy, and so on. Also, there are links out of the plant to government
regulators, community groups, customers, suppliers, the union and corporate experts. Finally,
there are inter-temporal links to shutdowns and new processes.

We cannot expect even the most experienced individual, let alone a relatively new
trainee, to understand all of these linkages in sufficient detail to account for them and make
intelligent trade-offs. This suggests the need for a team-based work organization. The team
should contain the requisite knowledge for all of these linkages. In addition, there should be
skill and experience gradients and interactions of sufficient quality within the team so people
can teach each other about particular aspects of the operation.

This idea, that no individual can understand all the dimensions of a complex problem,
exceeds beyond executing the organization's activities to their creation (e.g. procedure writing,
design of new facilities). Consider procedure writing: This is very complex because there are
often many ways to complete a given task, and it is important to write the procedure in a way
which permits all acceptable forms of practice, prohibits dangerous ones, and encourages the
most efficient. All three of these criteria tend to be very sensitive in their execution to details
embedded in the physical or technical context. Therefore, the procedures should be constructed
by a team. As one senior manager on the site put it:

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It seems to me that the best way to write procedures is to have a cross section of people with different skills and capacities who, in their totality, understand the process. (930317)

Management believed that each of these linkages (operations to maintenance, operations to engineering, etc.) could be managed with a coherent set of simple principles which would provide heuristics to generate behavior. For example, rather than thinking about safety, health, environment, and production yields as separate things, the site manager wanted people to ask how they could manufacture with the minimum amount of inputs and the minimum amount of by-products (broadly defined). Within this, they would ensure safety, health, and environment by trying to minimize damage to biological systems. People would combine these principles with their understanding of the total business to generate their behavior. So, the observed behavior at any point in time could be expected to look something like a natural language. While the behaviors we observe would appear to be random, they would in fact be consistent with and controlled by a set of grammar-like rules (the principles and the knowledge of the business). The organization would then evolve by learning good strategies for applying the principles, and by revising the principles regularly (see also Alker 1988; Pentland 1995).

Put this way, the whole thing seems extremely mystical and complicated. We imagine people juggling an extremely complex and abstract list of heuristics and principles as they work, trying to determine the appropriate response to the problem at hand. It is important to realize that a huge portion of the productivity gains and conflicts I observed in the Wideplant organization came through the application of principles which are reminiscent of the book All I really need to know, I learned in kindergarten (Fulghum 1988). It appears that, at that level, very high performance occurred if people concentrated on the job they were doing, considered others and treated them as they would expect to be treated, listened to each other, did their work in a thorough manner, read the labels of materials they used, thought things through before starting them, looked out for things that seemed unusual, and so forth.

**Accountability through ownership**

In addition to knowing what needed to be done, management felt that the crews needed two other characteristics: accountability and flexibility. Management believed people must be accountable for workplace outcomes. In an operation like a chemical plant, it is very easy to push a problem on to the next shift. There were even examples in the history of the plant of people shutting down the process in the middle of the night because of a problem and leaving it for the next crew. Furthermore, many of the other problems, such as “blaming” disappear if people feel accountable (i.e. feel responsible for ensuring that the ‘right’ outcomes occur). Rather than trying to punish people who behaved inappropriately, Wideplant management pursued two strategies to make the operators feel like they owned the plant.

First, management adopted a policy of giving groups of operators and mechanical tradespeople responsibility for important tasks. For instance, at one point, a supplier of an important raw material for the site decided to stop supplying. A group of operators and mechanical tradespeople was asked, in addition to their other duties, to find a new supplier, negotiate a contract (with assistance from the buying group), bring the supply on line, and bring on line a temporary facility because the new supply could not be procured quickly enough. All the people in the group knew that several areas on the plant would grind to a halt if they failed.

The general experience was that the controllers were happy to be accountable for tasks where they felt important, or which were intrinsically interesting. However, people weren’t yet shouldering their responsibilities for mundane tasks. When I asked the site manager about
this, he said that this was to be expected. His hope was that they would slowly build a feeling of ownership through the special tasks, and that it would spread slowly to the more mundane ones.

Second, management adopted a strong policy of telling the production workers that they owned the site. We will see a very dramatic example of this when we discuss the way the area 'A' production coordinator dealt with a tank containing a million pounds of contaminated waste. However, in the main, management aimed to generate a feeling of ownership through the employment guarantee it offered. This had four parts. First, management explicitly did not guarantee anyone a job. Second, management promised that it would work as hard as it could to keep people employed at the site by attracting new businesses, keeping old ones, and laying off contractors before employees. Third, management argued that it could protect and expand the businesses most easily if the site was safe, clean, and offered the highest quality services and products and the lowest possible price. Finally, management stated that if people had to leave the site but worked to develop the skills the organization was trying to foster, they would be the most employable people in the region. In fact, some people had moved on to foreman's jobs at other companies, and had found that they had more responsibility and more interesting work at Widesite in a production job. Therefore, continued employment was up to the workers. If they wanted to continue working, they had to pull their weight.  

It was noteworthy that management explicitly avoided inducing accountability using the Highplant strategy of "kicking asses and taking names". It was relatively easy for people to free-ride on the organization by not doing what they were supposed to. Notwithstanding, in severe cases, this behavior was noted and people who were malingering were often sat down by managers and asked to account for themselves. The punishment was never more severe.

Rewards for good performance and the rhetoric of safety

While, at Highplant, an individual who made an extraordinary contribution would be given a check or a gift certificate at a very public ceremony, at Wideplant, in sharp contrast, group rewards were very public. This difference in emphasis on individuals versus groups was consistent with cultural differences between the two geographic regions (e.g. Hofstede 1980). However, Wideplant management certainly did not discourage it. If a whole area managed to run for a protracted period without sickness, break a production record, or achieve some similar milestone, the plant would throw a party for everyone and their spouses, give everyone a check, or buy everyone a new jacket to wear to work. Individual rewards were very private. If an individual's work were extraordinary, they would be pulled aside and be given a pair of tickets to a sporting event or be asked to bring in the receipt from the dinner of their choice with the person of their choice. (Note also the emphasis on non-cash rewards).

Not surprisingly, this group orientation also turned up in the safety rhetoric. Widesite management would always justify the safety program in terms of the site interest. They would always say that safety was extremely important because it was a lead indicator that corporate

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7 This strategy makes a lot of sense if we consider the demographics of the plant sites. Most operators could expect to spend the rest of their working life in the plant. Most engineers could expect to spend between two and ten years associated with the plant, depending on whether they were at Highsite or Widesite, and whether they were junior or senior, and would probably finish their careers at a different site. Most managers could expect to leave that plant within two or three years, and the site within five.
management used when assessing the quality of a site's management as part of deciding where capital would be allocated, which plants would be shut down, and so forth. Therefore, people were taught to be safe if they, collectively, wanted a job. This does not mean that management did not hold individuals accountable for their safety behavior (though because of the change process there were internal political reasons why that was very difficult).

Just as the threat of sacking at Highsite was mainly rhetorical, it appears that Widesite's theory of plant siting was too. I asked a corporate manager how important site safety and environmental performance really was in facility siting. He said that it was a minor consideration. If a site's performance were clearly below average, it would be unlikely to attract new facilities. If however, it were fairly good, it would not weigh strongly against other strategic issues.

_The second critique: flattening the peaks_

Finally, to manage exceptions efficiently, the organization needs to flatten the peaks and fill the troughs in the workload. There were a number of broad strategies which could be used, and management wanted to pursue them all. First, management thought fewer exceptions would occur, and each exception would require less management, if people and teams were highly skilled. Second, if people who are not busy could help out the busy ones, fewer people need to be standing around waiting for something to happen. Finally, if people had something else to do, such as administrative work, there is nothing wrong with them hanging around working productively on administrative jobs, but still able to help out if something went wrong.

**The external environment as a determinant of work organization**

The external environment includes the social environment, the regulatory environment facing the plants, the environment the corporation created for the plants, the physical environment, and so on. The environments were not the same. We saw in chapter 4 that the sites faced radically different weather. We will see later that the fact that Wideplant was in a subsidiary meant that the site manager had more autonomy to act and more power on the site. Similarly, race relations were an issue at Highplant, but not at Wideplant. Furthermore, the plants had to respond to different regulations. However, with the possible exception of the relationship between the plant and the corporation, I will assume that these environments were equivalent.\(^8\) That is, nothing in these environments had any material impact on real structuring decisions.

*The union as the external environment*

The reader may be surprised that I do not highlight the presence of the union at

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\(^8\) I make this exception because it is probably not an accident that the experiments in organizational change were most successful in a subsidiary away from strong normative pressures from the corporate offices. This would be consistent with punctuated equilibrium models of change, which hold that change occurs initially in isolated sub-populations (Gould 1982).
Wideplant, or the aggressive legal environment near Highplant, as differences between the sites. There are two reasons why I do not. First, up until the late 1970's, the plants faced virtually identical labor relations and legal environments. Highsite was always strongly anti-union, and still is. In order to prevent unionization, pay was set at the local union rate and strict seniority rules were in place. The plant had a strong personnel office which would act as an advocate for employees, much as a union would. However, according to the operators, as the threat of unionization diminished in the 1980's, this office was stripped of a lot of its power.

Widesite was always unionized and had more than its share of labor unrest, culminating in a strike of many months in the early 1970's, but with smaller strikes since then. Shortly after, the site manager was replaced and the new manager was instructed to improve labor relations. This happened slowly over the next two decades. Since labor laws in that country have not becomes significantly more anti-union since then -- in fact many would argue the contrary -- we must see the good relations between labor and management as coming from strategic behavior by the two groups, particularly management.

Second, one could argue that unions perform an important role in constraining the excesses of management. Therefore, Highsite, which exists in an environment of rapid de-unionization, benefits from some sort of advantage over Widesite. This de-unionization is also a function of management strategy, though on a regional level this time (Kochan, Wells et al. 1992). However, rather than de-unionization having freed up management's hand, it seems to have constrained it further. An alternative institution, the courts and the litigation system, took the unions' place.

As you drive the twenty miles down the interstate highway from Highsite to the next major town, you pass no less than four billboards advertising the services of lawyers who will happily help you resolve your wrongful discharge claim or ensure the right person is held responsible for your accident. These services generally precede automobile accidents, other liability, and divorces on the list. If, for some reason, you don't like the look of these firms, you can turn to the inside or outside back cover of any of the local telephone books. Armed with the white and yellow pages for a couple of years for a couple of towns you will probably find another five or six firms. There is no shortage of liability lawyers near Highsite, reputedly the most litigious region in the U.S.

This high level of litigation has had a number of impacts on the plant. For example, the site manager's biggest concerns with this study described in appendix 2.1, were in-part around the risk of it being used to bolster a suit. He told me many stories of frivolous, unfounded, and bothersome suits and legal tactics in the region. However, the most interesting effect from a theoretical perspective is the way this rise in litigation has coincided with the decline in unionism in the area. In particular, the courts have taken a big part of the role a union usually plays. The threat of suits drove a lot of training, care in human resources management, care in the management of discharges, and the like.

However, fear of litigation engenders management behaviors we expect to see in workplaces which suffer the very worst aspects of union organization, and none of the benefits. There are a number of reasons for this. First, and most obviously, there is no communication

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In chapter 9, I will develop the argument of this chapter further and argue that site management is dominated by a culture of control. In such a culture, a union represents an alternative source of power and uncertainty and thus is something extra which needs to be controlled.
between the courts and the company until there is a full-fledged dispute. Therefore, there are no opportunities for constructive problem solving before issues escalate. Issues are treated in the most adversarial way possible. Second, only big disputes get treated. Issues which are conflictual in nature but not large get suppressed. Therefore, more creative problem solving around smaller disputes -- which could prevent the big disputes -- does not occur. Third, management doesn't derive any of the benefits which come from a union organization. In particular, it doesn't get access to information about what production employees are thinking, unfiltered by managers who have an incentive to make people seem happy (see chapter 12). Fourth, a lot of programs are designed with the corporate objective of litigation protection.

For instance, I participated in the contractor safety indoctrination for the site. Of the six videos I saw in three hours, two were about ideas and four were about facts. I remember the two about ideas. One explained why I should always use hearing protection and the other explained why I should wear a full harness instead of a belt when working off the ground. The other four were long lists of things I need to know if I work at the site. Facts about the location and sounds of alarms, the details of procedures, and the like were thrown out at a rate of about three per minute. I walked away from these four knowing that "I had been told" everything I needed to know to work on the site, but unable to remember any of it.10

Finally, and strongly related to the fourth point, management has to take a defensive stance as it approaches every problem and every issue. As a result, many work practices found in unionized work settings, such as a strict emphasis on seniority and clearly defined jobs, permeate the site.

Conclusion

In this chapter, we have examined the technological, historical, strategic, and the environmental forces that came to bear on the structure of the organizations. We saw how for their first thirty or so years, the plants managed conflicts between the four primary tasks -- routine and event-based production and learning -- by separating execution from learning, and by emphasizing the reduction of exceptions at the expense of building a capacity to manage them.

In the early 1980's it became clear that this strategy was dysfunctional. Highplant attempted, on several occasions, to implement alternative strategies, but without success. Therefore, by the time of the study, management was pursuing two seemingly-contradictory objectives in response to two pressures from the corporate parent. On the one hand, it wanted to implement the new forms of work organization. On the other, in order to ensure safety performance, it was actively reinforcing the pre-existing culture through coercive control. Wideplant, on the other hand, was able to integrate the "Organizational Effectiveness" initiative into its ongoing efforts to improve labor relations at the site. Through the 1980's management developed a strategy for team-based operations using high-skilled, multi-skilled workers. In the next chapter, we will examine the way these strategies were implemented.

10 This behavior makes much more sense when considered in the context of the discussion of formal rationality in chapter 11.
6. Work roles at the time of the study.

In the last chapter and chapter 3, we outlined differences in the technology, institutional environment, history and strategy of the two organizations. We saw in chapter 3 that the technology was essentially identical in the two plants, and in chapter 5 that, with exceptions of relationships with their corporate parents and race relations, the external environments were equivalent. The aim of this chapter then was to show the way in which similarities and differences in the structures of the organizations derive from differences in strategies and histories and similarities in technology and the external environment. I will do this by discussing the roles different people in the organization performed, and mapping them, as far as was useful, onto the tasks they performed, as discussed in chapter 4, and aspects of the strategy and history. In addition, I will highlight differences that will be relevant to the argument later on. Although there were differences at all levels, the main differences appear at the lower levels in the hierarchy, so I will concentrate there.

The managers

Site management

The two site managers differed mainly in their tenure and power. While the Highsite site manager had been in the position for less than two years of an expected three, the Widesite site manager had been in the job for six years of an expected eight. These differences in tenure, when combined with the differences in site size, led to a very important difference in their relationships with their sites. While the Highsite site manager could name virtually none of the production workers, his Widesite counterpart knew most people on site and many people felt they knew him.

The second difference, the greater power of the Widesite manager, stemmed from the respect the Widesite manager garnered, and the way the U.S. corporation and the subsidiary were structured and these tenure differences. When the company was a monopolist, profits were limited by the plants' abilities to manufacture. Consequently, the vice presidents for manufacturing for each of the major product divisions, and vicariously their site managers, used to be extremely powerful (Hickson 1971; Pfeffer and Salancik 1978). As those monopolies eroded, the business functions became pre- eminent, as had happened in other major corporations (Dertouzos, Lester et al. 1989). As such, manufacturing lost its corporate-level power. Within the U.S., the different sites were owned by different businesses (known as "landlords") which rented space to the businesses on the site. Hence, the role of the site manager was ambiguous. In the olden days, he had had complete control of the site. At the time of the study, some of that power remained, but the various business managers had a much stronger allegiance to corporate business management than to the site manager. In fact, the site manager had only veto power over the appointment of his direct reports -- the business managers.

At Widesite, the site manager was formally aligned with no businesses. The company as a whole ran the site. The site manager was seen as an ally of, and advocate for, all the
businesses and the employees. Furthermore, because the subsidiary was smaller, the site manager was a member of the corporate leadership team. In addition, the businesses within the subsidiary were much more functionally integrated. Some ran their sales support and marketing from Widesite. Also, a nearby site hosted the subsidiary’s research laboratories. All of these meant that the site manager’s power did not have to be at the expense of any other functions or businesses. Rather, his power arose because he was an important node in corporate networks and had the ability to mobilize resources for people. Any failure to perform these functions would have led to rapid marginalization. Consequently, the site manager tended to be a much more powerful force on the site at Widesite. At both sites, he controlled directly site-specific domains such as labor relations and safety and environmental management.

These differences between the site managers had very little impact on the day-to-day operations of the plants. However, the differences in regard to the change efforts were tremendous. The Widesite manager had some major advantages over the Highsite manager as a change agent, in that he was there long enough to effect change gradually, people couldn’t even consider just paying lip-service to what he said and then waiting for him to leave,¹ he knew all the people and their histories, and he had significantly more independence from corporate headquarters to create a locally tailored change effort.

Assistant site managers

The site managers were each assisted by an assistant site manager who was at the same hierarchical level as a business manager (the Widesite assistant manager had a much less hierarchically defined job title). The assistant site manager was responsible for site-level staff functions such as safety, personnel and human resources management, medical services, and site security. The striking difference between the two assistant managers was the people in the positions. At Highplant, the assistant manager was an engineer who had climbed the hierarchy through a plant leader’s and business manager's job. At Wideplant, in contrast, he had signed on as a production operator. Apparently, he was the highest ranked non-graduate in the corporation.

Of the functions overseen by the assistant site managers, differences in the safety, environmental, and personnel functions were the most interesting. After controlling for plant size, Highsite had much bigger safety and environmental staffs, and a much smaller personnel staff. The larger safety and environmental staffs at Highsite would seem to derive from a different basic attitude towards safety and environmental management. As we saw in chapter 5, and will see again in chapter 9, Highplant had a much stronger orientation to control. We will see later (chapter 11) that it also had a much stronger emphasis on compliance. Both require more people. The larger personnel staff at Widesite probably derives from the presence of the union, which needed to be managed actively, the site’s more sophisticated recruiting policy which required many more people to develop and run, and the emphasis on human resources management. Also of interest was the fact that the safety officer at Widesite had been president of the union before being promoted, first to supervisor and then to safety officer. The site personnel officer had left the company to work at an adjacent site, had become president of the union there, and had returned to be promoted into personnel. Both of these

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¹ Since the operators, particularly at Highplant, were there for much longer than the professionals, they experienced management and the engineers as transitory visitors to the plant who could generally be waited out if necessary.

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career stories would seem to indicate that management was more interested in promoting people with initiative and a concern for the effective management of those functions, than in promoting "yes men".

**Business unit organization**

Each production unit contained operations, maintenance, and technical groups. Whereas the business unit at Highplant contained the one production unit ('A' and 'B-C' combined) and an analytical laboratory, that at Wideplant contained three production units ('A', 'B-C', and one other). Although the Highplant business unit had one less production unit, there were six supervisor-level people at Highplant (called 'plant leaders'), compared to five at Wideplant ('coordinators'). In part, this was because capital budgets were much higher at Highplant, so there were many more engineers to supervise (figure 6.1). At Highplant, there was a production and a maintenance plant leader over the production units, a plant leader over the laboratory, two plant technical leaders, and a plant leader for continuous improvement. Wideplant had one coordinator for each of the three production units, one for engineering, and one for maintenance. These people all reported to a business manager.

<table>
<thead>
<tr>
<th>Business manager</th>
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<tbody>
<tr>
<td>Plant production leader</td>
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Figure 6.1 (a). Highplant business organization

<table>
<thead>
<tr>
<th>Business manager</th>
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<tbody>
<tr>
<td>Plant A coordinator</td>
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</table>

Figure 6.1 (b) Wideplant business organization

**Production leaders.**

During the study, I worked with four production leaders: a plant production leader at Highplant, a production coordinator in area 'A' at Wideplant, and two in area 'B-C' at Wideplant. (One retired in the middle of the study.) Unambiguously, they were the most powerful people in their respective organizations. While they reported up to the business managers and the site manager, and nominally had status equivalent to their technical and mechanical counterparts, they were responsible for getting the pounds out the door, and so everyone deferred to them. Because they were so powerful, their leadership styles tended to permeate the organization. I will discuss their use of power further in chapter 9.

Despite the fact that there were more plant leaders at Highplant than there were coordinators at Wideplant, the Highplant leader's job was much larger than that of the Wideplant equivalents. There were two reasons for this. First, the Highplant production leader was responsible for production in all three facilities, while the Wideplant equivalents were only responsible for one or two. Second, a lot of the work at Wideplant was pushed down
the organization. The controllers made all the operational decisions. This freed up the facilitators (first line managers) to make sure that the operations decisions were sensible, but, as we will see, this meant a need for many fewer facilitators. Instead of worrying about every production decision, and supervising an army of supervisors, the Wideplant coordinators had time to think about the more strategic aspects of running the plant and particularly to monitor the organizational system at work. In contrast, the Highplant production leader only had time to worry about running the plant. Therefore, in addition to their responsibilities to the business outside the plant (which were presumably very similar), it is no surprise that the people in these positions at the two plants spent their time dramatically differently.

Supervision

The organizations really diverge at the supervisor level. First, there were more supervisors at Highplant. Some of the difference may derive from the recency of the amalgamation of the two areas, and therefore positions not having been eliminated yet.

The Highplant plant production leader had 10 direct reports: one support engineer, two plant specialists, two planning and scheduling supervisors, four shift supervisors, and a training supervisor. Reporting to the plant mechanical leader were six people: one support engineer, two mechanical supervisors, one planning and scheduling supervisor, an instrumentation supervisor and an electrical supervisor. Reporting to one of the technical leaders was the DCS design supervisor. All except the shift supervisors worked a day schedule. With the exception of the engineers, all of these began their careers as operators or mechanics, generally in either area A or area B-C. The two support engineers were being groomed for plant leader positions. One's primary task was to run the business for process B3, and the other's was to provide long-term support for the maintenance organization. In addition, these two ran the area safety committee, managed short term initiatives like ISO 9000 quality certification, sat on a number of site-level committees, and performed other similar functions.

<table>
<thead>
<tr>
<th>Production leader</th>
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<tbody>
<tr>
<td>Support engineer</td>
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<tr>
<td>Shift supervisor</td>
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</table>

*Figure 6.2 (a.1) Highplant production supervision*

<table>
<thead>
<tr>
<th>Maintenance leader</th>
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</thead>
<tbody>
<tr>
<td>Support engineer</td>
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</tbody>
</table>

*Figure 6.2 (a.2) Highplant maintenance supervision*

Of the other eighteen people, only the jobs of the plant specialists and the planning and scheduling supervisors need elaboration. The rest worked as fairly traditional foremen. Although these jobs in each process area were differentiated, these supervisors worked as a
team, splitting the grey area between their jobs according to their strengths, their experience, and their proclivities. In essence, they were responsible for the day-to-day operation of the plants. Their tasks included purchasing raw materials and shipping the product, deciding whether the plant should run or whether pieces of equipment which were misbehaving should be taken down for maintenance, scheduling the maintenance, walking the plants to find the repair jobs the operators hadn’t reported, planning and supervising the shutdowns, and managing initiatives such as the implementation of the quality program, the technology improvement program, or the new process safety management rules. They received advice and assistance in these tasks from the other supervisors, the engineers, the plant leaders, and on rare occasions, one or two of the operators.

At Wideplant, the ‘facilitators’ all worked a day schedule. About half had hired in as operators or mechanics and about half were hired as professionals and then promoted. Of the professionals, all but one -- a Master of Industrial Relations -- were chemists or engineers. Area ‘A’ had four production facilitators at the start of the study, though they eliminated one. One of them also oversaw the area ‘A’ maintenance organization. Area ‘B-C’ had five production facilitators plus one maintenance facilitator. They also eliminated one position by the end of the study, and one facilitator took on the additional task of allocating production between the various plants around the world.

<table>
<thead>
<tr>
<th>Production Coordinator</th>
<th>Maintenance Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew B &amp; &quot;personnel&quot; facilitator</td>
<td>Crew C &amp; &quot;operations&quot; facilitator</td>
</tr>
</tbody>
</table>

**Figure 6.2 (b.1a) Wideplant area "A" supervision, early in the study**

<table>
<thead>
<tr>
<th>Production Coordinator</th>
<th>Maintenance Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew B &amp; D &amp; &quot;personnel&quot; facilitator</td>
<td>Crew C &amp; &quot;operations/planning&quot; facilitator</td>
</tr>
</tbody>
</table>

**Figure 6.2 (b.1b) Wideplant area "A" supervision, late in the study**

<table>
<thead>
<tr>
<th>Production Coordinator</th>
<th>Maintenance Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew A &amp; &quot;site&quot; facilitator</td>
<td>Crew B &amp; &quot;personnel&quot; facilitator</td>
</tr>
</tbody>
</table>

**Figure 6.2 (b.2a) Wideplant area "B-C" supervision, early in the study**
Figure 6.2 (b.2b) Wideplant area "B-C" supervision, late in the study

The production facilitators had three sets of responsibilities. The first was to be an active member of the 'core group'. The core group, which also included the production coordinator, and -- at various times -- the area engineers, the maintenance facilitator, and the day staff, would try to meet weekly. At one typical meeting they discussed: a) the possibility and implications of installing intelligent control in one part of the process, b) changes in the ventilation regulations and who they should sent to a training course, c) how to celebrate their anticipated "up-time" record, d) a new program to construct a computerized piping inventory, e) changes in the people responsible for their business at a corporate level, f) financial performance, g) how to manage the loss of two mechanics to an overseas project, h) plans for a change in supplier, and so on.

Senior management had put a fair amount of thought into the appropriate structure for the core group. As with the controller group, skill gradients were desirable. That is, the seasoned ex-controllers could teach the young engineers interpersonal skills. The engineers could teach the older facilitators about rock music. Of critical importance was the proportion of people drawn from the two populations. Management's aim was to have about 25% of the facilitators drawn from professional positions. That way, the controllers could legitimately aspire to management jobs. When I asked a senior manager about the very talented pool of trainees they currently had -- clearly many more than the number of facilitator slots that could come available -- he said that they planned to keep expanding the responsibilities of those who remain in controller slots. He noted that people could aspire to leadership slots because they want the status, qualitatively different work, or work that was more engaging. While they could not provide people in a controller job with the status, there was no reason why they could not give them the other two.2

Second, the facilitators managed the running of the plant. These activities were divided into four categories: operations, planning, site, and personnel. The operations facilitator was responsible for the day-to-day running of the plant, currency of the procedures, and the quality program. The planning facilitator was responsible for the scheduling of production, raw materials purchasing, dealing with customers and suppliers, and safety. The site facilitator would manage shutdown planning and coordination of relations between production and maintenance. Finally, the personnel facilitator would manage pay, vacation, organizational development, extra days off (because a 12-hour shift leads to a 42-hour week),

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2 This highlights an issue which is underplayed in the dissertation. One of the big problems which was clearly emerging at Wideplant at the time of the study, and was a problem at Highplant for different reasons, is that there were no clear career paths for the junior engineers. In particular, if people wanted to move out of engineering into any sort of management position, there were far fewer opportunities than there had been previously. Similarly, those in facilitator positions were there for much longer than they planned. As an attempted to overcome some of the boredom, the facilitators in area B-C discussed the possibility of rotation of their jobs among themselves.
and overtime. Area 'A' combined operations and planning when they eliminated the position. In fulfilling these responsibilities the facilitators were assisted by an operator who was working days, known as the 'day point' and, supposedly, one quarter of the operators on each crew.

Third, each facilitator was responsible for personnel issues on one of the four crews. This was not a trivial task, because personnel management extended beyond Human Resource Management. It was also understood as responsibility for facilitating the development of each individual and each crew so they could improve their ability to manage themselves, interact with other groups, and understand the total business. It was often said that the role of the facilitator was to train their way out of a job.

As with the idea that the organization should be "principle based", it was very tempting to think of this development task as being the very sophisticated application of the latest human resources management techniques in complex and ambiguous situations. Sometimes it was. There were difficult developmental issues that had to be worked through, and inspired facilitator work did not go astray. However, to a surprising extent, personnel development was often quite mundane, though considerable skill was needed to prevent people from becoming defensive. For example, on two occasions I saw some facilitators spontaneously taking a large chunk out of their day to fill a "training need". After conducting a safety audit, the facilitator spontaneously said to the controller who had recorded the items, "What say we go and enter it in the computer?" He spent the next hour walking the controller through the computer-generated database form, teaching him elementary word processing skills, and waiting as he picked out the observations with one finger. The other occasion was very similar, and involved a controller learning how to use the program for scheduling the incoming rail cars.

The producers

In the remainder of the chapter, we consider the three groups who constituted the technical core of the organization: the engineers, the operators, and the mechanics. These three groups were all involved, to varying extents, in the four main organizational functions: exceptional and routine production management and learning.

Engineers

The plant technical leaders at Highplant had essentially three classes of engineers reporting to them. The first class were known as 'plant engineers'. They were generally graduates with less than four years experience. They would provide technical assistance to the operators running the plant. In addition to trouble-shooting problems, they would design temporary projects (like rerouting piping or special cleaning operations), participate in cyclical Process Hazards Analyses, and ensure that all special operations were performed safely. Plant engineers would hold the position for two years. After that, they would be rotated to a position in another process area on the site or at another site (depending on the way they were hired).

After two stints as a plant engineer, but sometimes after only one, an engineer would be promoted to project work or the management track. On the technical track, he or she would become involved in progressively larger, more complex, and more far-reaching projects. Finally, at the time of this study, some of the senior engineers moved from the business unit to
the research laboratory (the third class). Some cynics thought this had more to do with hiding the true number of engineers during a corporate restructuring than any fundamental change in the work. However, in the main, they were moving gradually from site-side to business wide engineering concerns.

While Highplant management wanted engineers to get 'broad exposure' (as much a statement about managing political allegiances on the site as their work experiences) and therefore required that the engineers move between business units between their first and second rotations, Widesite engineers did not move. In fact, engineers usually worked for a year or two on area projects before becoming a plant engineer. They could expect to work in that job for about four years. However, the job evolved as they grew. In particular, they would take on increasing numbers of projects and other responsibilities over time. There were two other differences in the engineering organizations. First, there were more engineers with direct production responsibilities at Wideplant. Area 'A' had three, two of whom focused on the waste treatment plant and environmental projects. Area 'B-C' had four, one of whom was not an engineer but a supervisor who had worked in the plant for 40 years and had not been a terribly effective facilitator. In contrast, at Highplant, there was one plant engineer in area 'A' and two in area 'B-C'. Second, there were many more engineers (21 versus nine) at Highplant. In part, this was because Highplant had recently been rebuilt, (three positions were slated for elimination the year after the study) but to a large measure it was apparently because the corporation had always invested much more recurrent money in the U.S. sites than in that foreign subsidiary. Of the U.S. sites, Highsite was one of its flagship facilities.

The engineers at Wideplant fulfilled another important role, that of 'foreman'. The production coordinators would often say with pride how rarely they were called at home. As opposed to their counterparts at Highplant, who could expect to be called weekly, Wideplant production coordinators would only get calls two or three times a year. Similarly, the facilitators were rarely called in to help with operating problems. It would seem that the crews were managing themselves and making the decisions they needed to. In part, this was true. The operation at Wideplant was much smoother than at Highplant. However, in part, it was because the engineers were receiving the calls. They would frequently get called at home and be asked to come in and help with problems. Often, they were astounded by the questions they were asked. For example, one process area on Widesite started up with a modified process. Six months later, on a Saturday, the power went out and the whole site went down. One of the area engineers was asked to come in because that day's crew of operators did not know how to start up the new process. While the usual cases were much less dramatic, it was important to note that the engineers filled the traditional foreman role for the plant, that it took up a large portion of their time, and they did not like it because it was generally unacknowledged work.

<table>
<thead>
<tr>
<th>Technical leader (2)</th>
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<tbody>
<tr>
<td>Plant engineers</td>
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</table>

Figure 6.3 (a) Highplant engineering organization (total = 23)

3 The subsidiary started a new plant during the study. They hired graduate engineers to work as shift operators in addition to providing technical assistance.

4 This is not surprising, given that the engineers had extensive project responsibilities in addition to ensuring the day-to-day operations of the plant.
Mechanics

There were two dimensions on which we will compare the two sites' mechanics and operators. First, we will examine the way the core production and maintenance work was done. Second, we will examine the additional tasks the operators and mechanics performed.

Mechanical work was divided into two parts, preventative and predictive maintenance and repair maintenance. Preventative and predictive maintenance was the 'exception prevention' component of the mechanical work, while repair maintenance was the exception management part. Transitech corporate experts estimated that if the plants did their preventative and predictive maintenance properly, they would use only one third of the mechanics Highplant was using at the time of the study. In addition, plant capital productivity would be much higher because uptime would rise and the need for redundant equipment would fall.

However, the corporation had historically had tremendous difficulty getting high levels of preventative maintenance. There appear to be three reasons for this. First, it was in the narrow interest of the mechanics for the equipment to break down. It made their work much more interesting, increased their power (Crozier 1964), and increased their income through overtime. Second, scheduled preventative maintenance never seemed to happen reliably. Equipment would be scheduled for maintenance before it was necessary and urgent work was always pressing, so preventative work tended to be deferred. Third, effective maintenance programs need good communications between the operators and the mechanics, since the operators are working with the equipment the whole time and, therefore, are more likely to notice problems. In the year or two prior to the study, the corporation launched some initiatives in preventative maintenance. Wideplant benefitted from them enormously, but Highplant, while obtaining the corporate certifications, still had trouble with mechanical breakdowns and high levels of overtime.

The mechanics were not major participants in formal learning activities, though they had more involvement at Wideplant than at Highplant. Mechanics at either plant who were proximate to events would participate in the incident investigation. At Wideplant, they would also be actively involved in pre-startup inspections of new and altered equipment, process hazards reviews, and other activities.

A typical day for a mechanic was fairly similar at both sites. At Highplant, they tended to get together for coffee and a game of dominos at about 7:00 and the jobs were handed out at 7:30. At Wideplant, they did not worry about the dominos and started work at 8:00. Supposedly, at both plants, the jobs had been prepared the day before by the planning and scheduling people, and the equipment would have been tagged out by the operating night shift. The mechanics then worked four blocks of time punctuated by morning and afternoon coffee and lunch. At Highplant they played dominos in their breaks, while at Wideplant they played cards. In the last half hour of the day, the mechanics assigned their time to job numbers in the computer, checked their e-mail (if they had not done so during the day), and washed up.
In addition, two Highplant mechanics performed a task the Wideplant mechanics shared; that of 'historian'. The historian kept maintenance records for the equipment and ensured that the computer generated routine maintenance work orders for all equipment, and only for equipment that still existed. One Highplant historian managed mechanical equipment while the other managed instrumentation and electrical equipment. By the same token, Wideplant mechanics performed two tasks carried out by the Highplant supervisor and his or her day mechanics (office staff). The two Wideplant roles were called the operations point and the planning point. There were four -- one of each for each area and trade (mechanical and instrument/electrical for areas 'A' and 'B-C'). In each shop, they were filled by two of the mechanics or electricians, essentially on a permanent basis. The mechanical planning job tended to be full time, while the electrical equivalent and the operations points were done alongside other work. The planner organized the various jobs, allocated money, ensured there were parts, and so forth. The operations point coordinated with the production site point to work out which jobs should be done, when, and by whom, for both routine and shut down maintenance.

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<thead>
<tr>
<th>Maintenance supervisors (2)</th>
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<tbody>
<tr>
<td>Mechanics</td>
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<tr>
<td>Historians (2)</td>
</tr>
<tr>
<td>Day (office) mechanics</td>
</tr>
</tbody>
</table>

Figure 6.4 (a) Highplant maintenance organization

<table>
<thead>
<tr>
<th>Maintenance facilitator (50%)</th>
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<tbody>
<tr>
<td>Mechanics</td>
</tr>
<tr>
<td>Planning point</td>
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<tr>
<td>Operations point (2*25%)</td>
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</tbody>
</table>

Figure 6.4 (b.1) Wideplant area A maintenance organization

<table>
<thead>
<tr>
<th>Maintenance facilitator</th>
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</thead>
<tbody>
<tr>
<td>Mechanics</td>
</tr>
<tr>
<td>Planning point</td>
</tr>
<tr>
<td>Operations point (2*25%)</td>
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</tbody>
</table>

Figure 6.4 (b.2) Wideplant area B-C maintenance organization

Operators

_Twiddling the knobs_

Routine operations were very similar at both sites. Each process area and its ancillary processes was run by a crew of between three and five operators, except that Highplant railcars were loaded by a contractor. Because of technological differences, and differences in the processes assigned to each area, the number of positions for a given process varied for the two plants. Notwithstanding, at either plant, one of the operators on the crew was known as the 'control room operator' (controller) or 'panel operator' (controller) and the others were 'field operators' (controllers). Each field operator was responsible for a geographical location like a building, one floor of a building, or the tank farm (which includes loading and unloading trains). Each field job was about the same size. The operators rotated fairly uniformly through all the jobs, after accommodating trainees. An exception to this was that the older controllers at Wideplant and the operators on over-time at Highplant tended to end up working the panel. Because the panel job was boring, stressful, and involved a lot of interaction with others, it was
undesirable to those who were still strong and healthy.

The rotation periods varied markedly between the sites. At Highplant, management decided the rotation schedule and operators would change once every two shifts (if there were four shifts in the set) or three (if there were three). However, operators in one production area at Highsite worked the same job for an entire month. At Wideplant, crews would change when they wanted, and that varied from twice per shift to once every set of shifts. The rotation frequency was contentious. Some people argued for infrequent rotation, so that people would feel obligated to fix problems rather than pass them on to the next person or the next shift. Others argued for rapid rotation because fresh and less bored eyes were more likely to spot problems.

Each afternoon, the Highplant plant specialist or the Wideplant operations point would bring the daily 'guidelines' into the control room. This page-or-so of text would include target production rates for the next 24 hours, current hazards to watch out for, events expected in the next day, equipment which had to be taken down for maintenance, and non-steady-state operations that needed to be performed (like defrosting equipment). Given no unexpected surprises, this provided the template for the night and the next day.

The work on the night and weekend shifts was generally easier than on days, since there were no meetings to attend (at Wideplant), no safety audits to perform, no inspections to carry out, and no engineers scurrying around performing tests and asking questions. As a result, the plant tended to run much more smoothly than during the day. On both shifts, the field operator (or controller) had a set of tasks that had to be performed once or twice. These included inspecting all the equipment and taking analytical samples for the laboratory. These were performed at the very beginning of the shift and about half way through and took about an hour. The rest of the shift would be spent starting, stopping, and washing out equipment according to the panel operator's requests, dealing with operations problems, cleaning out equipment to make sure it ran properly, sweeping the buildings, tagging out systems, performing routine inspections of safety equipment (e.g. fire extinguishers or breathing air systems) or just sitting around talking about sports, religion, the process, or the news.

The panel operator ran the process. He or she would respond to alarms (often at a rate of one every few seconds), try to line out the process or keep it lined out, initiate routine washing of equipment, and coordinate interactions with other processes, on the one hand, and between the crew and the supervisory and engineering staff on the other. The Highplant panel operator answered to the shift supervisor, though one of the four supervisors always deferred to the panel operator, and two did most of the time. At Wideplant, the panel controller was in charge. He or she made decisions alone, with the assistance of the crew, and occasionally with the assistance of the plant engineer, the shift facilitators, or the production coordinator. Whereas the shift supervisor chaired the morning meeting at Highplant, the Wideplant meeting was run by the panel controller.

Day work

There was a lot of administrative work to do. At Highplant, the day work was split between the supervisors and a number of operators and mechanics who had permanent day assignments. Besides the historians described above, Highplant had three planning and scheduling operators (two for 'A' and one for 'B-C') with counterparts in the mechanical shops. These people would take the maintenance requests that came from the field and combine them with those generated automatically by the computer (and approved at the planning and scheduling meeting), construct the work orders, and ensure that the parts were available. Three people, two operators and a mechanic, worked for the training supervisor. One provided
all of the mandated training for the operators and mechanics (fit testing for respirators, use of breathing apparatus, knowledge of the hazardous waste laws, etc.). The second was responsible principally for managing the business unit’s environmental program and managing its compliance with the regulations. He applied for permits, coordinated the pollution prevention program, managed reporting for the business whenever there was a spill, and so forth. The third worked full time as an editor of the area “A” production manuals, but also performed some committee work. Three mechanics worked for the DCS supervisor, writing code for the DCS. A draftsman worked to update the plant drawings. Finally, four operators (one of whom also did production work) nominally spent their time writing and updating the operating procedures. However, they also spent a large portion of their time sitting on area operations committees, helping the engineers with technical problems, and assisting with small projects. These employees all held these positions for a minimum of two years, and often much longer.

At Wideplant, management used administrative work as one of the two principal devices for getting people to “know the business”. That was, by getting everyone to do a share of the administrative work, management hoped that controllers would see running a plant as being much more than “twiddling the knobs” and therefore would reduce the amount of ‘blaming’, would be more engaged in the work they did because they identified with the business, would understand the way operations interacted with other production functions and therefore reduce the need for a narrow specification of the differences, and would be less bored.

The controllers rotated regularly through two classes of jobs. In addition, some spent time on days for special projects. In this section, I will describe the way these rotations were meant to work. I will describe how they were extremely contentious at the end of the chapter. They were the major source of conflict between management and labor.

As noted above, each controller was assigned a ‘point’: operations, planning, site, or personnel. Having a point implied two responsibilities. First, every few months (four months in ‘A’ and six in ‘B-C’) four different operators rotated to days. In that day role, they would perform three functions. First, they would assist the facilitator with the day-to-day management of that point. For example the planning point would manage all the ordering of supplies, the tracking of raw materials across the continent, and the disposal of products to customers, as well as the associated paperwork. Second, they would undertake long-term projects associated with the point or with capital works. For example, one site point spent several weeks working out how to perform the shutdown maintenance on a piece of equipment the first time it was going to be overhauled. Other points spent time assisting with the design of new capital works. Finally, they would sit, either individually or collectively, on area committees. For example, the area ‘A’ personnel point would chair the area safety committee for their period on days and would take responsibility for doing or delegating any work it generated.

Nominally, these day points were assisted by their counterparts on each shift. So, the personnel points on each crew would manage all the overtime, sickness and disability leave, and vacation for that crew as well as scheduling the job rotations. Similarly, the site points would be extra vigilant on their rounds, looking for work that needed to be done. However, as we will see in chapter 12, those working shift tended to leave all but the personnel work to the person on days.

Secondary skills

The second strategy Wideplant management used to help people “know the business” was to require them to acquire a secondary skill. That is, operators would be expected to have some proficiency in a mechanical trade, laboratory work, or some other technical function. As
with the point work, secondary skills were supposed to reduce 'blaming'. In the process of acquiring their secondary skill, people would spend a protracted time with people from the other group. In so doing, they supposedly learned how to see the world through the other groups' eyes. Therefore, errors would decrease and communication and compassion would increase.

Secondary skills offered another obvious advantage in managing exceptions. If something went wrong and those functional skills were needed, the person with the secondary skill would be expected to fix minor problems, begin the diagnosis for major ones, and help the specialist technician if one had to be brought in. So, for example, during a crisis, an hour or two might be saved by sending someone up to the laboratory to run a sample or by purging some instruments.

Filling the valleys: Minimizing the wastage of staff

While Highplant operators had few responsibilities other than their production work, management at Wideplant had selected three strategies to minimize excess staffing. The first was to give people something to do during the quiet times: their point and project work. If people had a full plate at a given time, it did not matter if a crew comprised more people than were needed for the quiet moments. Those with 'nothing' to do could pursue other duties. The second strategy was to equip people, through secondary skills, so that they could help others manage their exceptions. So, if it was quiet in one area or function and all hell was breaking loose in another, people could lend a hand.

The third strategy to avoid staff wastage was to move people from point work to shift. If someone on a shift was away, a person who was meant to be working days would be asked to put on coveralls for the day. Sometimes, they would be asked to work the full 12-hour shift, and would get four hours of overtime. The people who had the point jobs resented this. They experienced the constant pull into the field as a huge disruption of the administrative jobs they were trying to do, and they found the overtime really tiring. It was relatively easy to work an extra shift or two of overtime. However, they found that four hours of overtime on one or two days when they had to work five days a week was really difficult.

At one point in the study, the management group in area 'C' at Wideplant came up with an extension of this idea. They proposed to have one position on each eight-person crew assigned from full time production work to office tasks (administration, training, design of process changes, etc.), with the other seven people taking on the extra routine work. The person in that position would do desk work unless there was a problem in the plant. If there was a problem, the person would put on coveralls and help out. However, management decided it couldn't persuade the crews that this was a good idea, and abandoned it.5

Interestingly, site management had turned away from 'cross training', training operators from one process area in the operation of another. If the second process area were in trouble and the first were quiet, operators from the first could help out.

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5 Such an arrangement makes the organization very vulnerable to having the extra position either eliminated or turned into a day job during a cost-cutting effort.
Dissatisfaction: day work versus shift work

The controllers' response to the day work was fascinating. On one hand, they universally claimed to hate it. On the other, if you observed someone who had worked on shift for 20 years come into a day job, you could literally see the person grow in the process of mastering the new challenge. I was told of this, but did not believe it until I saw it myself. The particular case involved the controller who probably had the worst social skills and most negative attitude to management of all the people in area 'A'. However, he was generally seen as an extremely competent operator and intrinsically very intelligent. He indicated his disdain for the rotation by arriving on the first day with his hair cut in a 'Mohawk'. He also hung large model airplanes above his desk and pictures of trucks on the walls. However, his work performance made everyone's jaw drop. He was in the operations point role and, within two days, was running all the operations in an extremely competent manner and his actions indicated that he was really enjoying the work. Of course, if you asked him, he would say that he hated it.

There were five classes of reasons why the controllers generally disliked the rotations and secondary skills. First, there were two key technological differences between 'compound' manufacturing and the prototype area in which the work design was developed. Second, although people grew through the work, they did not like it. Third, there were strong group norms against liking it. Fourth, they thought their pay declined if they worked days, and finally, the move to days was extremely disruptive of their life outside of work.

Technological reasons

The technological differences illustrate the incredible context sensitivity of the work design. The first difference was in the nature of the processes. In the area where the work system was originally developed, it was reasonable for people to do some of the mechanical maintenance and laboratory work implied by the secondary skills. However, because the Wideplant equipment was much older, the process was mechanically much more complicated, and the process fluids were much more dangerous if someone made a mistake and was sprayed, people were extremely reticent to do any mechanical work on the process unless supervised by a mechanic. There were other things they could do, but they required very low levels of skill -- skills they already had. In the meantime, it appears that the mechanics tended to use the opportunity of having a controller working with them as an opportunity to play old rivalries. In particular, the controllers complained of spending six months carrying tool boxes and doing the mechanics' dirty work. So, the controllers were not interested in acquiring secondary mechanical skills and they saw the mechanical training as a waste of time. Very few controllers understood that management wanted them to learn to see the operations problems from a mechanic's standpoint and very few of the mechanics seemed terribly interested in showing it to them. However, some friendships did seem to be forming across the divisions.

The second technological difference stemmed from differences in the way the product was used. The people in process 'A' sent their product to process 'B'. Those in process 'B' sent it to process 'C'. Those in process 'C' sent the vast majority of the product to one customer who needed virtually no technical assistance. The remainder of the product went to customers in an industry which had very exacting requirements, but because the product was in a powder, as were their major ingredients, they did not have any particular trouble using it. Furthermore, when they used it, they introduced it directly into their core production process. In contrast, the prototype area had a huge number of clients for their liquid product. The product entered the customers' operations as part of a specialized input process which was very similar at each plant but very different from the rest of the plant. Therefore, the clients had a tremendous
need for technical assistance in the use of the product, and the domain in which that assistance was provided was well circumscribed. As a consequence, the controllers in the prototype area spent a lot of their time turning 'regular' customers into 'happy' customers, and travelling around the country doing so. This increased their job satisfaction enormously and led them to develop an integrative appreciation for the other aspects of the job. The Wideplant operators did not gain any of that satisfaction or integration, so these extra job requirements just seemed like a burden.

Learning reasons

A friend of mine who teaches mathematics at MIT once commented on yet another new initiative in secondary education. "What these people fail to realize," he said, "is that learning is hard." The point he was making was simply that real education involves the changing of cognitive schema, and that is hard work, stressful, and unpleasant. If the aim of day rotation and secondary skills was to give people 'true knowledge of the business' then the acquisition of that knowledge required them to invalidate some of their assumptions about what it takes to run a chemical plant as they learned new ones. This would be anxiety-provoking and stressful.

However, there was another reason why they did not like the form of the work. Shift work had a number of characteristics which office work did not. First, if you did not finish the job by the end of the shift, it wouldn't be waiting for you when you returned. Someone else would have dealt with it in the meantime and no responsibility lasted for more than a few hours. There was never an 'in' pile. Second, the pace was different. If things were going badly, there was an adrenaline-filled rush to get the plant back on-line and lined out. Otherwise, the pace was slow and relaxed. In contrast, with day work, the pressure was on from the time people arrived in the morning until the time they left at night. There were meetings, demands, and requests the whole time. There were people who could walk by the office and see if the points were working. Third, you could not take shift work home with you. One controller told me at length at the horror he had of driving around his property on his lawn mower and realizing he was thinking about a procedure he was writing. This was complete anathema to someone who had, for the past 20 years, been able to completely forget about work as soon as he left the plant gate. Fourth, the work itself was less engaging. From what I gather, operating work was done either automatically, or people were engaged in what they were doing. Furthermore, the work was very unpredictable and changed throughout the shift. Therefore, it had an excitement about it. With office work, it was possible to predict what was going to happen on a given day at the start of the day.

Groups and group norms

The third class of reasons came from group norms. Simply, people decided early on, for whatever reason, that day work was bad. Therefore, to say outwardly that they enjoyed the day work would violate the norms of the controller group. As a result, the norm of disliking day work was reinforced.

Groups were important in a second way. People's social lives and car pooling were often constructed around their crews and other crews on the same shift across the site. So, if a person went to days, they would have no one to come to work with and no one to socialize with.
Pay

Going to days also affected people's pay. This occurred in two ways. First, people who worked days had to take the public holidays, and therefore forfeit a holiday loading of $500.00. Second, people on shift got to work overtime. The controllers claimed that six months on days cost $6000.00 in lost overtime and penalties. In fact, the level of overtime in the plants was very low at the time of the study, so they were probably wrong. The management pressure on overtime was probably the major source of their reduced pay. However, the controllers believed it was the move to days.

To alleviate some of the disquiet, management agreed to give the controllers their shift loading while they worked days. This created an enormous conflict when people went to the maintenance shop to get their secondary skills training. The mechanics objected to spending their time giving mechanical training to someone who was earning more than they were.

The day schedule

Finally, there was a small group who said in a very quiet voice that they liked the day work, but that they did not like the day schedule. The main problem was that people had built their lives around the shift schedule and the transition was problematic. In general, people who did not like working the shift schedule posted to maintenance or the laboratory or another technician's job, so they could work a day schedule. Those who worked shift wanted to work shift.

I collected a number of stories about why people did not like the change. One controller complained to me that he had worked the same shift schedule for 20 years, and that he had developed a rhythm where he would automatically fall asleep some days and stay awake on the appropriate nights. When he went on vacation he would sit up for the appropriate nights. However, when he moved to days, that rhythm was disrupted and so he would not sleep at all on the appropriate seven nights of the month and would not be able to stay awake during the day, and then he would be perpetually exhausted, and miserable. Another controller complained that the first three months on days almost destroyed his marriage. He and his wife simply weren't used to seeing each other every night. After three months of fighting, they got used to being together more and started to enjoy the time immensely. A third controller had an outside business. The shift schedule enabled him to run the business because people who work a 12-hour shift had many days off each month. However, if he worked days, he couldn't do the extra work, which required daylight. A fourth controller had a wife who worked an opposite shift. One was always not working. This meant that one was always available to look after the children. If he went to days, this would no longer be the case.
7. Assessing performance differences

Introduction to the second part of the dissertation

In this section of the dissertation, we will compare the performance of the two plants. In this chapter, I will use a multiple stakeholder model to consider the criteria we could use to determine the performance of a plant. I will conclude that performance for most -- but not all stakeholders -- is maximized by minimizing the number and size of exceptions that occur. I will then create a framework for considering the way the differences in performance can create a difference in outcomes. The other stakeholders’ concerns are then discussed. In the second half of the chapter I will discuss the problem of injury prevention to show that there are many other strategies that can be used, albeit less efficient ones, for achieving organizational goals. Chapter 8 discusses the differences in technical and interpersonal skills between the plants. I demonstrate that, on average, people at Wideplant had higher technical and interpersonal skills, and that this probably explains a great deal of the performance differences. Chapters 9, 10, and 11 are a group. In chapter 9, I describe differences in “stance”, the way people in the two plants stood in relation to each other. I operationalize this by looking at differences in trust, power relations, and cultures of control. In chapters 10 and 11 I discuss the implications of those stance differences. Chapter 10 discusses the way stance differences play out in the execution of the 12 organizational activities described in chapter 1. We will see that, almost without exception, the Wideplant approach is likely to produce higher performance. Rather than looking at action directly, chapter 11 examines the underlying thought processes which are implicit in the actions I observed. In particular, I will argue that people at Highplant approached problems differently to people at Wideplant. While the Wideplant approach is probably superior, both approaches entailed significant risks. Finally, in chapter 12, we move up a level of analysis to examine the way structural differences between the plants, in the form of differentials in flexibility, created differences in performance.

Exception management as performance

If we were to consider the perspectives of the many stakeholders in the plants, we would look for things like technical efficiency, rate of change of technical efficiency, regulatory compliance, waste production, accident rates, and employee morale to be good predictors of performance. However, we saw in chapter 3 that the plants were technically tremendously complex. The complexity, when combined with management’s demands on the system, meant that the plants were operated at the edge of the production teams’ abilities. For example, we saw in chapter 6 that the mere presence of the day staff, with its demands for tests on the process, or that people leave the process to attend meetings (and be replaced by another person) was sufficient to cause process upsets. This incredible dynamic sensitivity meant that the performance of the plants depended on the production teams’ abilities to avoid and manage exceptions. This was the baseline for operations and was a precondition for many other objectives.
For example, if the crews could line out the system reliably, it was possible to optimize it. Not only could the crews maximize performance within their current understanding of the technology, but the engineers could run tests to improve that understanding. By the same token, reliable operations meant that they could make technological changes which increased the complexity of the operation, but enabled them to increase quality or differentiate their product in the market in some other way. For example, Wideplant introduced an alternative drying process in the late 1980's, and was followed by Highplant a couple of years later. Compared to the old dryers, these were incredibly difficult to run. However, they produced a much higher quality product. Similarly, at the time of the study, Wideplant introduced an extra finishing stage which would increase the quality of the product one stage further, and make it more attractive to a small market segment they were trying to monopolize. However, neither of these enhancements would have been possible if they had not been able to run the process. In the language of Perrow (1984), the evolution of the plants can be understood as a process of linearizing a complex system and then re-increasing its complexity up to the capacity of the operating team and the control technology. Reliable operations also meant higher safety and environmental performance. The probability of acute environmental releases or accidents rose markedly during startup and shutdown operations, or during the shut-downs themselves.

Therefore, the fundamental measure of performance was the ability to manage exceptions. The obvious way to examine performance, then, would appear to be to count up the number of exceptions at each plant, and compare them. There are two problems with this, however. First, by knowing that Wideplant had more or less than Highplant, you don't learn anything about why. Second, as we saw in chapter 2, events are hard to separate from each other since they occur in a stream of activities, the number of events is a function of the control technology, which varied between the plants, and the criteria for enactment of exceptions into events tends to vary with the management regime in place at the plant and other social variables.

Therefore, it is more fruitful to examine the organizational processes associated with the management of exceptions, rather than the exceptions themselves. In particular, we would like answers to the following "outcome" questions:

- Which plant is better at avoiding exceptions altogether, and why?
- When an exception occurs, which plant is better at containing it so it doesn't escalate to something they would call an event, and why?
- If people enact an event out of an exception, are they enacting the right events, and why?
- Once they are managing an event, which plant is more competent at dealing with it, and why?
- Once the event has occurred, which plant learns more appropriate lessons from it, and why?

We saw in chapter 1 that the organizations carried out twelve fundamental activities associated with routine and exceptional production and learning tasks. Routine tasks differed from exceptional tasks in that exceptional tasks contained the element of surprise. Learning differed from production in that learning tended to be temporally separated from action:
Production activities:
- Routine initiation
- Routine implementation
- Exceptional initiation
- Exceptional sense making
- Exceptional problem solving
- Exceptional implementation

Learning activities:
- Routine initiation
- Routine implementation
- Exceptional initiation
- Exceptional sense making
- Exceptional problem solving
- Exceptional implementation

My task in the following chapters, then, is to show how differences in the organizational structures and management strategies lead to differences in the management of these twelve activities, and how those, in turn, affect the answers to the five "outcome" questions above. Rather than bore the reader, I have decided to not draw the analysis all the way back to the five questions. Instead, I stop at the differences in the 12 activities.

Of course, the organization's structure and management's strategy do not act directly on the performance of these twelve activities. Rather, the performance is determined by organizational process variables such as the characteristics of the people (particularly their skills, their motivation, and their availability to do the task at hand) and their interactions. These are determined, in part, by managerial action. There are a huge number of process variables which determine performance of the twelve activities, but only a few varied between the sites in an observable way. Only the ones that varied are reported here. All of this can be represented causally as follows:

![Figure 7.1 Overall causal diagram](image)

The reporting of the comparisons and the causal relationships in the following chapters is complicated by the fact that the observational data are generally of the performance of activities, from which I made inferences about the organizational process variables. The interview data, on the other hand, are often directed at the process variables directly (e.g. skills and the process of their acquisition). Finally, chapter 12 is concerned with structural differences explicitly. I have avoided forcing one form of data into the format of the other. That is, I have not written all the chapters in terms the organizational process variables and how that variable contributes to particular activities, nor have I written a chapter about each of the twelve activities and described all the variables that contribute to its execution. Instead, I have been pragmatic. When it is easier to talk in terms of one or the other, I have done so. However, when possible, I have written in terms of one activity and the one process variable which dominates the differences in performance. This has allowed me to
make valid matched comparisons.

Other performance measures

Being able to line out the process is, of course, not a total measure of performance. While it creates the possibility for optimization and technical improvement which either increase productivity, or safety, or environmental performance, it doesn’t guarantee them. Similarly, it says nothing about chronic releases or hazards in the process. Other organizational processes need to be in place, such as those which will ensure that new capital equipment will be operable. Similarly, it says nothing about employee satisfaction or morale. Only two of these need to be considered in detail here. The rest will be discussed, as appropriate, in the text.

The problem of peaks and troughs.

No matter how good a crew was at keeping the process lined out, exceptions would still occur. Sources of variation would constantly be penetrating the organization. For instance, even with perfect operations, the operators still had to contend with unreliable equipment or impure input materials. This created three imperatives, one aesthetic and two efficiency-based. For small exceptions, when things started to go wrong, the operator responsible for that particular area was likely to be run off his or her feet. In these cases, an extra pair of hands was the difference between ending a shift tired and ending it exhausted. For large exceptions, efficiency questions arose. The size of the peak workload determined how many people needed to be available at a given time to keep the plant running. However, the size of the largest valley determined how many people were potentially wasting time waiting for the big events. Therefore, management could increase labor productivity if it could find some way to flatten the peaks in labor demand and fill the valleys in people’s work schedules. Management aimed then to flatten the peaks and fill the troughs.

Safety performance as a performance measure

If the organization cannot prevent exceptions, it must manage them. Therefore, before launching into an elaboration of the ways the different organizational strategies, cultures, and structures produced different outcomes, it is useful to look, in detail, at the causal processes behind one type of outcome -- accidents -- and the sorts of strategies that organizations can use to prevent them. Safety management is interesting for a number of reasons. First, there were no measurable differences in accident rates between the plants. As such, it shows the possibility for equifinality in a tightly coupled system. Second, because the outcome is relatively concrete (in that the reader can imagine it), it is possible to give a relatively abstract description of the causation process without the reader getting lost. The more general case of a process upset admits so many more possibilities, and therefore more confusion. Third, because a lot has been written about the social side of accident causation, I can fill in a lot of the causal gaps. While exception avoidance is clearly the most cost-effective strategy for safety management, this gives us a chance to see the possibilities for interventions after the exception has started to occur. We will see that different types of causal processes will lead to different approaches to the intervention. In particular, as one Transitech engineer pointed out to me, you manage safety
in an explosives plant differently from in a regular chemical plant. Highplant's response to OSHA's process safety management code would seem to support this idea. In particular, they set up a completely separate committee, chaired by a line manager and staffed principally by line engineers, rather than the head of the safety office. Furthermore, the committee focused principally on the engineering and management systems that the plants had in place, rather than compliance issues or the behavior of individuals.

**Coupling in physical systems**

In chapter 3, I described a chemical plant. I broke it up into four systems: the production system, the steam system, the control system, and the safety system. The Transitech reviewers told me I came up with a reasonable description. If I were to walk into a steel mill and spend six months there, I could probably develop an equally adequate description. However, I couldn't do so after a day, or even a week. The reality is that such a description comes only from knowing how the process works.

The problem is this. If I were to walk naively into a chemical plant, I would see something very different. Instead of seeing four separate systems, I would see a whole lot of pieces of equipment joined together by racks of pipes and cables. The pipes and cables all look the same, though some are bigger than others, and some have different colored labels to others. In addition, all of the different pipes and cables seem to feed each piece of equipment. That is, they all seem to be a necessary ingredient for all equipment. As a naive theorist, I would conclude that the plant doesn't comprise four systems, but about 100: a control room, 97 pieces of process equipment, racks of cables, and racks of pipes. To the eye, that is the way things are organized.

The four-system approach doesn't come from the physical relationships between the equipment at all. Rather, it comes from the causal relationships. In particular, within each system, a signal at one end tends to propagate to the other end very quickly. An increase in steam temperature in the powerhouse translates rapidly to a pressure increase throughout the steam system, while a relief valve tripping leads to a reduction. Similarly, tripping an interlock rapidly activates a number of emergency safety systems, including a number of alarms in the control room. There is a high probability that a perturbation at one point in these systems will lead to a perturbation at another. We can predict a clear, continuous, and proximate causal relationship between these elements in the system (Weick 1976). Technically, we say that within these systems there is *tight coupling* (Thompson 1967; Perrow 1984).

In one of these systems, the production system, the coupling isn't nearly so tight. In fact, the designers deliberately put storage and holdup tanks throughout to prevent perturbations from travelling too far too fast. There is still a probability that a perturbation at one end will create a perturbation at the other, but there are so many tanks, columns, and reactors in between that there is a distinct chance that the perturbation will never propagate. Whereas a strong cause-effect linkage is referred to as tight coupling, a weak one is known as *loose coupling* (Weick 1976; Meyer and Rowan 1977).

Three of these systems, the production system, the steam system, and the control system, are loosely coupled to each other. For example, a rise in the steam pressure (and therefore temperature) in one part of the steam system could lead to a temperature elevation in one part of the process. That temperature elevation would speed the reaction, and lead to an increased rate of production, which fills a storage tank faster. This increased production would slowly make its way down the production system. That is, a small perturbation in the steam
system propagates slowly down a part of the production system. Similarly, a small perturbation in the control system will lead to a change which ripples through the pipes.

However, one of the systems, the safety system, isn't supposed to have this relationship to the other systems. Short of them physically blowing the fire system out of the way (which has happened in some chemical accidents) the safety system should work independently of the state of the other systems. A lot of care goes into keeping it physically separate. That is, as far as possible, the designers try to decouple the safety system from the others. In summary, if we examine any two physical elements in a chemical plant, we can say that they are tightly coupled, loosely coupled, or decoupled, depending on the causal relationships between them.

Coupling of organizational action and technical systems

However, there is more to an organization than machines. There are also people. The way the machines operate determines, very precisely, the way people will act during routine operations. We can say that routine work is tightly coupled to the technology. On the other hand, exception management is only loosely coupled to the technology. Given a problem, the field operator can work out what to do, the panel operator can tell the field operator what to do, the operating team can get together and decide, a plant engineer can be called in, the site experts can be telephoned, or someone can be rushed from corporate headquarters. While there are a large number of options, there are a limited number of sensible choices to pursue in the management of a given exception. For instance, you wouldn't call in a corporate expert because the panel operator forgot to rinse out some equipment and so it shut down because it vibrated too much. The panel operator would initiate a wash cycle and then ask the field operator to start it up again. Notwithstanding, the organization has much more choice than it has in the routine case. Finally, learning from exceptions is virtually decoupled from the technology. That is, the way the plants go about learning has very little to do with what actually goes wrong in the plant. Rather, the plants invoke procedures which have much more to do with the their internal organization than the incident itself.\(^1\)

Accidents and coupling

An organization comprises a large number of system elements coexisting in a social space. To the ones already described, we should add the elements of the environment which penetrate the organization's boundary. These systemic and environmental elements include the technological hardware, the operating procedures, the personnel system, the people, their attitudes, the pension plan, and the weather, among other things. Many of these elements are coupled tightly to each other.

Just because some elements are loosely coupled or decoupled, it doesn't mean they are not interacting. In fact, they are interacting the whole time, and generally in unpredictable ways.

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\(^1\) We will see later that the plants had different accident investigation procedures. However, the plants were similar in the way they responded to the size of the incident. Larger incidents tended to have different incident investigations. Below a certain size, they were done by one person. Above a certain size there tend to be lawyers present.
A researcher walking down a footpath on a plant site interacts with the weather, the cleaning system, the shift schedule, noise from the equipment, general procedures for moving around the site, and so forth. Workers in the thick of the production process are subject to even more interactions, most of which are completely harmless despite their huge number. That is, at any given time, there is extremely high interactive complexity (Perrow 1984). Because the core technical systems (the production system, the safety system, the steam system and the control system) are tightly coupled, they are not interacting in unpredictable ways with elements of themselves or with each other. Rather, those interactions are quite predictable. That is, after all, the definition of tight coupling. Furthermore, many of these unpredictable interactions have no observable impact whatsoever. Other interactions cause organizational failures, most of which have no consequences. For example, a process operator who is tired and rushed and therefore decides to skip part of her inspection rounds will generally do so with no ill effect—unless she is caught by management or an equipment failure.

Sometimes, an interaction, or series of interactions, occurs in such a way that the organization chooses to label it as an accident. Generally this is done on the basis of the interactions' consequences rather than their causes. For example, someone might get hurt or some equipment might be damaged. Often, one of the interacting elements is part of the core technology. This is not because of the coupling in the core directly. Rather, accidents involving the core technology tend to be more severe for three reasons. First, the core tends to be a place where a lot of energy is stored and can be released quickly. The energy either does damage itself, or is instrumental in the transport of toxins. Second, because of tight coupling and the stored energy, interactions within the core can propagate and create other interactions which release still more energy (Perrow 1984). Finally, the core contains elements which can decouple themselves and then interact with it (for example a failure induced or assisted by poor maintenance or metal fatigue).

Types of accidents

Given this description, we can define an accident as the interaction of two or more organizational systems which were previously thought to be independent, such that energy is released and propagated, and damage is done. An injury is an accident where a person is damaged. If the failing elements are previously known to be causally related, we do not call it an accident. We tend to label it as stupidity or malice. The courts call it liability. However, there are at least three stages in an accident. First, there is "accident waiting to happen". While it is theoretically possible for the various elements to interact at the same moment, the probability is very low. Rather, many of the interactions occur prior to the initial release of energy (Reason 1990). Second, there is the final failure which leads to an initial release of energy (we called that an exception). Third, one of five things can happen: 1) nothing more will happen and the problem will be fixed, 2) the failure will not be fixed, and will remain latent to interact with another failure to cause what Perrow has called a systems accident, or 3) the release of energy will precipitate further failures and the failure will escalate, or 4) the energy (or the material it transports) will interact with a victim, or 5) the organization will intervene and either stop the propagation or prevent it from interacting with a victim.²

² Perrow (1984; 1994) distinguishes between component failure accidents and systems accidents. Systems (or normal) accidents, he claims, occur through the simultaneous failure of organizational sub-systems that were thought to be independent. As can be seen from the above description, and will be made clearer when we examine sense-making in chapter 17, all accidents occur through failure resulting from the interaction of systems that were
Therefore, when organizations try to avoid accidents, they can pursue one (or more) of three strategies. The first is to avoid the simultaneous interactions which can cause damage, in the first place. The second, is to avoid the final action which causes the propagation of energy to begin. The third is to somehow arrest the propagation of energy or stand in its way so more failures (such as the material splashing on a victim) cannot occur.

Avoiding simultaneity

The easiest way to avoid untoward interactions is to proactively eliminate known causes of them. In chapter 5 we saw one strategy, namely requiring people to be obedient so that they behave in accordance with management's understanding of the technology. If we assume (as a Fordist production system does) that management understands the system better than the workers, then this is a way of minimizing unpredictable behavior which could induce a failure. A second common strategy is to perform preventative maintenance. By avoiding the degradation of the equipment (a process which could be described in terms of simultaneous interactions and failures if we wanted to), the organization reduces the probability that the equipment will actually fail. The third common strategy is to learn from the failures that occur. The organization analyzes failures to see the component systems which failed, and then changes the component systems to prevent that class of failures from recurring. (Alternatively, it could decide that the best intervention is some sort of buffer which prevents that accident from propagating or doing damage.) A final, and less common strategy is to teach people that there are particular times when complex interactions are most probable, and to train them to be particularly careful in these moments so that their behavior will not be the precipitating cause. For example, equipment is generally most dangerous when it goes from one steady state to another (starting, stopping, start and end of loading and unloading, etc.). People in one Transitech plant were taught that this is the time when they must absolutely concentrate on their work.

Preventing initiation

However, if the organization is characterized by high interactive complexity, it is simply not possible to avoid all untoward interactions. There are two (highly related) strategies which organizations have developed to help people spot situations where accidents are about to happen. The first one is very close to the Buddhist concept of mindfulness. The idea here is simply that if you pay attention to your circumstances, you will notice any unexpected deviations. These deviations indicate an untoward interaction. People at Highplant were taught that they should stop work immediately if they had any suspicion that something "felt" wrong, and that they should investigate it thoroughly before proceeding. Weick and Roberts (1993) describe a similar concept of "heedfulness", which entails people thinking mindfully in terms of the risks others face.

Preventing propagation

If an energy release occurs, there are a number of strategies the organization can use to prevent further harm. The first strategy is to decouple the energy release from the victim, for

thought to be independent, and all accidents occur in systems characterized by extremely high interactive complexity. I explore the theoretical implications of this in a separate paper (Cebon 1995).
example, by getting the victim to wear protective clothing. In some accidents, the time/space gap between the simultaneous failure and the victim is too small for this to be an effective strategy, such as someone falling over and breaking a foot, or cutting themselves with a knife. Normally, however, there is a time/space gap between the failure and the victim, and people can prevent the propagation from causing damage by placing something in that gap. Three near misses at Widesite illustrate unplanned, and less desirable, decoupling. In one case, several years before the study, a boiler blew up but the workers were protected by a piece of equipment which was between them and the explosion. In the second, which occurred during the study, a fan blew up, but they had evacuated the area. In the third, also during the study, a controller was checking out a job on a catwalk on the fourth floor of a building before dawn. The day before, as part of the job, a group had craned a piece of equipment out through a hole created by removing a section of the catwalk. They had neglected to replace the grating. The controller, who was a keen body-builder, walked under a safety rope and straight into the hole. He saved himself from almost certain death by catching himself by wrapping his armpit around the outside of the handrail of the floor below.

As an alternative to decoupling, the organization can use buffers to absorb the excess. A prototypical example is the containment dikes around tanks. Alternatively it can direct it out of harms way, as with relief valves. A final strategy is to actively attempt to suppress the event or at least halt its propagation. While this can be done with the skills (or in the case of Chernobyl, the bodies) of the operating crews, it is normally done with fire systems which cover the release in water or foam, or interlocks that shut down machinery.
8. Skills

The differences between the two organizations occurred in three domains. The first, skills, is discussed in this chapter. The fundamental task the plants faced was one of keeping the process going as steadily as possible. The chances of doing so increase markedly with the technical skills of the operators or mechanics willing and available to do the task. That is, three variables are likely to determine their proficiency: their skill, their motivation, and their availability. In particular, the chances of getting into trouble are probably a function of the skills and motivation of the worst operators in a team. When it comes to getting out of trouble, the technical and interpersonal skills of the team as a whole, as well as its motivation, are likely to be important. In this chapter I will talk only about technical and interpersonal skill differences between the plants. The way in which Wideplant was better able to get people to the task at hand will be discussed under a more general discussion of flexibility in chapter 12. The problem of motivation will be included in the discussion of the impacts of different management and worker stances in chapter 10, as well as within the discussion of flexibility.

Technical skills

That Wideplant's controllers were generally more skillful was uncontroversial. Operators and staff from the two plants had interacted. In particular, two controllers spent a couple of weeks helping the Highplant operators with a startup. Also, teams of operators would get together for regular 'operator exchanges' where operators from several plants would get together and learn from each other. Finally, one production coordinator went to the other plant and had a chance to talk to the operators. The general consensus, and one that was consistent with my own impressions, was that the skill level of the top 30% of operators at each plant was approximately equivalent. However, the differences in the bottom 70% were dramatic. Given that productivity was highly dependent on the weakest member of a team, particularly if people did not help each other, this was a major problem for Highplant.

A particularly important example of the effect of a skill differential can be seen in the operation of one type of machine. Highplant had somewhere between five and ten, each costing about $1,000,000 each. They contained an internal assembly which cost about half that and had to be made and then imported from Europe if it failed. This would take several months. They were the best on the market in their class. If the machine was not operated very skillfully, it would tend to vibrate very badly. I was next to a machine when it went into uncontrolled vibrations. The whole floor shook and the noise was deafening. Presumably, every one of these events could have caused some stretching of the internals, or loosening of the bolts. The Highplant machines were beset with problems which resulted in a number of the internal assemblies being irreparably damaged and a huge amount of lost production. Highplant operators and engineers claimed there were design problems with the machines. However, from my discussions with people at Wideplant, it is not so clear. It is distinctly possible that the machines were not designed to be operated the way the Highplant operators treated them. In particular, several controllers and supervisors who had visited Highplant commented, without any prompting, that they were horrified by both the poverty of understanding of these machines by some (not all) of the operators, and the operating strategies.
they used. In particular, they were shocked that the operators would wait until the computer control system told them to clean the machine (on the basis of increasing vibrations) rather than monitoring it closely and learning to anticipate problems, since they wanted to avoid vibrations at all costs.\footnote{Although I never raised the issue with the people at Wideplant, they would almost certainly have argued that you should be even more aggressively proactive with the clean-out if you know that the machines are under-designed and will be damaged by vibrations. However, it was only when they had no spare assemblies left (having scavenged some from a new plant) that Highplant went to a very aggressive washing and maintenance regime, initiated by the engineers.}

It's easy to see how such a skill discrepancy could emerge. First, the two sites recruited people in dramatically different ways. Second, people received nominally similar, but actually very different, training.\footnote{Although here I have presented the recruiting and training of production-level employees, similar differences existed for promotion of production employees or engineers to supervisor positions, promotion of managers within the corporation, and career development of the management and engineering groups.}

Skills through recruiting

Both sites recruited about three years before the field-work for this study. Highplant carried out a fairly traditional 'hiring hall' recruiting. They advertised in the local paper and took 4500 applications for operators, mechanics, electricians, and technicians over two weekends. At an initial interview at the Veterans of Foreign Wars hall, recruiters ensured that applicants understood the job they were applying for and recorded race and gender for affirmative action purposes.

Suitable applicants were invited to take a test. Although the formal requirements were much less stringent, suitable applicants generally had a high school diploma and either five years of relevant experience or an associate's degree in chemical process operation from the local university (a program funded largely by Transitech). The corporate-developed tests would examine aptitude in the relevant trades. For example, the mechanical test revealed whether people could figure out how pieces of equipment fit together. The electrical test was by far the hardest. Operators were also tested in simple mathematics, and the potential technicians in simple chemistry.

Those who passed the test were interviewed by two panels of three. Two panel members were from employee relations and one was an operator, a mechanic, or a supervisor from the field. After each 30-minute interview, the panel would rank the interviewee on the basis of presentation, how he or she answered questions, and demonstrated knowledge of the subject. One member would ask questions to elicit temperament and interpersonal skills. In addition, the panel would examine recommendations from employees on site, transcripts, recommendations from previous employers, and background checks for criminal records.

Applicants were then ranked within their groups and the best were selected. Despite insufficient female and minority candidates of sufficient quality, they hired enough of them to
fill up a quota. At the margin, relatives of employees stood a better chance of being hired because they knew the company and the site and could get references from employees. However, despite some nepotism, though much less than had been the case traditionally, inappropriate relatives were never hired.

Unlike Highsite, which was interested principally in whether people had job relevant skills, Widesite wanted people who were interested in learning, who were good at working with others, who were flexible in the way they viewed their work, and who wanted broad work experience. Relevant work experience was of secondary importance. Widesite ran an upbeat advertisement in local and regional newspapers announcing Widesite as the workplace for the future. To be eligible for employment, applicants needed to have grade 12 with mathematics, chemistry, and either physics or an additive subject such as computer programming, business administration, or a technology subject. Of 1000 applications, 65% had some post-secondary education. Applications were read and ranked, and tests were administered to the top quarter. In addition to aptitude and mechanical reasoning tests, the plant administered a 'life styles inventory' psychological test.

The second stage of the process involved two activities. First, successful testees were interviewed by a panel of four members of the plant interviewing team. Second, they participated in a group problem-solving exercise in which their behavior was coded by a panel of observers. Both panels contained a mix of human resources staff, facilitators, and controllers. Any member of the interview or observation panels could veto a candidate up to this point. For the third stage, the human resources staff sent a block of files (about five times the number of vacancies) of candidates who scored well in these first two stages to the plants. The plants then gave each potential applicant a 60-minute tour of the facility in which their reactions to aspects of the job were observed, and a 60-minute interview by the production coordinator, the personnel facilitator, and the personnel point from one of the crews with a vacancy. The different plants then bid against each other for the applicants.

The recruiting effort was an overwhelming success. Eighty-five percent of hires had some post-secondary education. For example, in Wideplant, one hire had an engineering degree, a couple were bored school teachers, and one was trained in psychology. Two were self-trained computer experts without a college education. Relatives of employees were hired in the same ratio as they applied (40%). The mean age was 27, consistent with the company's desire to hire mature people rather than "young and healthy people with ten fingers and toes", which was the traditional aim. Also, rather than aiming for "traditional family values", they did not hesitate to hire openly gay and lesbian applicants.

There were however, two major problems with the hiring. First, managers believe they oversold the controller concept so that incoming trainees underestimated the amount of routine plant operating work. This led to some attrition (to law and engineering schools) and morale problems by the time of the study. Second, they did not hire as many women as they would have liked. In part, this was because the equipment was designed for big people. In part, however, it was because a process like this tends to lead interviewers to hire people like themselves.

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3 Though, undoubtedly they were within Corporate EEO guidelines.
Skills through training

Nominally, the operators received very similar training. Initially, they spent a couple of weeks in the classroom and learnt the site safety procedures and some basics of operating. Then, they went out to their work area and were assigned to a job. For the next few weeks they would perform the job with an experienced operator, who would teach them the work. At the end of about six months they would take a pair of tests. In the written test they would have to demonstrate that they 'knew the process', that was that they could sketch the process with the major pipe-work and pieces of equipment, that they could say what all the equipment did and how, and that they understood the procedures. In the practical test, they would demonstrate that they could perform key jobs competently. After completing the test, the operator trainee would work the job exclusively for a few months to reinforce the learning. Trainees would learn all the field jobs in the area before learning the control room job (which required intimate knowledge of the process), and would have to progress at a certain rate to maintain their employment and progression to full pay and qualification in about five years.

However, the attitudes of the trainers were markedly different at the two sites. This led to the transfer of different norms and skills. At Highplant, the senior operators, who were now the trainers, were very explicit. When they had trained, they had learned by following around the senior operators and by peppering them with questions. Senior operators at that time had not been particularly interested in training new personnel. As a result, new trainees had had to take their training into their own hands. When their reluctant teachers went into the lunch room, the new recruits tried to teach themselves the complex tasks and equipment they needed to learn. Now that they were the senior operators, they expected the same of the new generation and were appalled when the trainees retired to the lunch room with them.

This apparently benign indifference had an insidious under-belly. The first group of black operators had hired in about fifteen years earlier. Some of the women had hired in with the latest group of recruits about three years earlier and others had hired in fifteen years prior. Both of these groups felt actively discouraged by the senior operators. As a result, they developed group norms based on other issues. So, while the white men would sit around and talk about the process (and therefore build their skills), the black operators would talk about religion or sports and joke and play and had a good time. Meanwhile, the white women, who were too few to form a group, would spend their time alone starved for knowledge. (The black women appeared to identify more strongly with the black men as their reference group, rather than the white women.) As a result, a skill hierarchy was readily apparent with most of the highly skilled operators being white men.

Some would argue (particularly the white men) that these differences were reflections of extra-organizational cultural effects and products of the recruiting process rather than being derived from intra-organizational dynamics. To some extent, the quota system would produce this result. However, it was also driven by internal processes. Two Widenplant controllers told me of their experiences when they went to Highplant to help start up a new building (which used some Widenplant technology). They were amazed by the enthusiasm with which the black and female operators would pepper them with questions to find out about the new process. They were much more enthusiastic than the white men. That is, to a large extent, differences in skill were not caused by a lack of aptitude or a desire to learn.

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4 Changes in U.S. law meant that the training protocol would change at Highplant just after the study was completed; henceforth operators would be supervised until they took the test. However, I doubt this would mean any change in the content of the training.
At Wideplant, the training was different in two key respects. First, across Widesite, there was a hierarchy in the quality of the four crews. Interestingly, the best crew in each process area was always the same one. Its opposite crew (the one that worked nights when it worked days) was always the second best. In one of the other two crews in area 'B-C', the lead operator was a particularly competent trainer. It appeared to me, though I never asked, that the best trainees were placed on these three crews, with the most competent crew getting the most, and highest caliber, trainees to ensure they acquired the best skills. One trainee, who had been transferred from the worst crew to the best, told me of his amazement at how much higher the knowledge standard was on his new crew. This would tend to reinforce the notion that motivation and aptitude are not enough to become an excellent operator.

Within these crews, the senior controllers and the facilitators took the task extremely seriously. Unlike the Highplant operators who saw training as an unpleasant chore, the Wideplant controllers, who also disliked it enormously, put a tremendous amount of effort into giving the trainees the best education they could. They saw the quality of training now as determining the quality of their crew in the future. In addition, recently certified controllers who seemed adept would often teach the field jobs. People believed these trainees knew better how to learn the jobs and that the exercise would consolidate their training. Finally, different jobs would be taught differently. For instance, while people would learn the field jobs from one or two people, on some crews, everyone would teach the panel job. It required high tacit skills, was very complex, and had a lot of latitude for personal choices. People believed that trainees would learn best by seeing how each of the other controllers on the crew performed the task, rather than just one.

**Within-group interpersonal skills**

We expect that people's ability to work together will also affect productivity. In particular, if teams can work cohesively, they will be better able to participate in joint problem-solving, and better able to learn from each other. At Highplant, I saw no evidence of work to increase team skills. This is not surprising since, under a foreman-based system, coordination is achieved by the supervisor, not by people working together. Therefore, the major need for coordination was not present. At Wideplant, management had put a lot of effort into creating crews which would work as skilled teams. In area 'B-C', the three controllers who assigned people to crews used three decision-making criteria. First, they ensured that the four best operators were on different crews. Second, they built crews of people who they thought could work together. Third, they ensured that there was a diverse set of skill gradients on each crew. That was, everyone on the crew had something to learn from someone else.

Management also attempted to give the teams skills for working together. In particular, at the time of the study, everyone on the site received a copy of Covey's (1989) *Seven habits of highly effective people*, and a three-day training course on its lessons. Around the walls were signs of previous training efforts. For instance, in the plant conference room were a list of the ten things effective group participants did, e.g. listen, encourage, participate, be constructive. On my last visit to the plant the area 'B-C' was handing out another guide to the staff, it was a list of the '12 new rules' which were extracted from a book on growth and renewal as an adult.

These two strategies (selection and training) appeared to work. For example, one night I was in the control room at the start of a shift. One of the dryers had gone down and people weren't quite sure what was wrong. The two most competent people on the crew were working on
the dryers that night anyway. However, they started the shift by calling a meeting of the entire crew to discuss their approach to the problem. As one of the younger operators explained to me, this served three very important functions. First, the crew probably came up with a better understanding of the problem as a result of the meeting. Second, this younger operator learned a tremendous amount about the dryers from the older operators. Finally, the shift was a lot more fun when they had meetings like that because everyone felt like they were involved in dealing with the problems.

Between-group interpersonal skills

One of the major purposes of the secondary skills program at Wideplant was to give the controllers an opportunity to get to know the mechanics and other trades, and to let them see the world through the other group's eyes. It is very hard to tell whether the program was having any effect. I could not measure it by trying to compare the level of conflict between the operations and mechanical groups at the two sites, because conflict is likely to occur in the context of coordination activities. Therefore, while conflict at Highplant can be expected at the supervisor level, it can be expected at the controller level at Wideplant.

The Highplant operators told me that they got on well with the mechanics, but that the supervisors were always at each other. This may be true, but I didn't see any strong evidence of it being the case or getting in the way of getting the work done. Maybe I didn't see the appropriate sort of crisis to bring the antagonisms to the surface. The operators were clearly antagonistic towards the maintenance supervisors. They complained that they would have to tag out jobs two or three nights in a row, just to have the day crew detag it because the mechanics didn't get to it. However, people did talk about the conflicts of days gone by.

At Wideplant, similarly, I didn't see any evidence of conflict between the two groups but people talked about the conflicts of the past. While there were built in conflicts between the two groups, which management believed had been solved through the secondary skills training, we will see when we discuss flexibility (chapter 12) that they were avoided largely by structural means and entrepreneurial behavior on the behalf of the mechanics. Similarly, because of the reduced hierarchy, other problems disappeared. For instance, one day, I was in the control room and a mechanic came in to say he was going to start a job. The panel operator warned him off it, saying that that part of the process was running well at the moment, and so he should leave it alone. I doubt this sort of behavior would have been possible at Highplant, where two supervisors would have to be brought into the discussion as well.

Conclusion

This chapter has discussed the first of three classes of differences that appear to explain performance differences between the plants. Given higher skills, Wideplant management had much more room to manoeuvre to create other desirable features within the organization. However, the skills didn't get there by accident. We are still left asking why the senior controllers at Wideplant took their training role so seriously, and how it was that Wideplant could attract more sophisticated people. Even if the major source of differential performance were just skill differences, and the differences laid out in the following chapters were not important, it may well be that those differences are a necessary condition for the skill
differences to emerge.
9. Stance: Differences in power, trust, and control.

I originally described the differences between the sites in terms of power, trust, and control as distinct independent variables. However, the interactions between these variables was probably as important as the variables themselves. Consider, for instance, the difference between the way you think about someone who is powerful, and you trust, versus someone you don't. Furthermore, the three variables were clearly inter-related and, while conceptually separable, were linked by both the histories of the plants and the human resources strategies management had in place. These histories and strategies were laid out in chapter 5. Finally, and possibly most important, I was struck that there were very few behaviors which could occur at one site and would be completely inconceivable at the other. A few things happened at each site that would not be tolerated at the other. However, in the main, most observed behaviors at one plant were within the discretionary repertoire of actors at the other. Therefore, I felt I had to capture the effect of structural differences on one hand, but have them mediated by the discretion of the actors. I concluded that the important thing to examine was the stance people took in relation to the problems they faced and other people in the organization. That is, how did individuals approach and deal with the problems in which they were embroiled, and how did that behavior, and the same structural conditions, determined the tone of the sites and the responses they elicited.

In this chapter, I describe the differences in stance, and their causes. Stance differences, when coupled with the strategies, had a constellation of impacts which affected performance. We will see these in the two following chapters.

Power

As noted in chapter 6, the production leaders were the most powerful people in the organization. Everyone deferred to them. We saw in chapter 5, however, that Highplant had tried, unsuccessfully, to empower the production employees in the 1980's, and that Wideplant claimed, at the time of the study, that it was empowering its workers. In this section we examine the reality of the supervisors' power, and its implications.

The Highplant production leader kept an extremely tight rein on the production process. This could be seen in an extreme interest in the intimate details of the process. At five o'clock, morning or evening, the crew supervisor would give a detailed report by telephone. In addition, the plant leader never hesitated to primped decisions by the supervision or the operators. However, I was told by many operators and supervisors that this plant leader was much less controlling and less likely to pre-empt people than the prior one.

One very dramatic example illustrates this pre-emptive behavior. The large dryers were rotated by belts, which were attached via pulleys to gear-boxes and motors. One day, a supervisor discovered that one of the gearboxes was breaking, and that the belt had slipped half way off its pulley. The gearbox needed to be replaced. There were no short-term fixes. In the meantime, the other dryer was out of service, being repaired for another problem. The plant was behind on its production.
The meeting to discuss the problem was a bit like an interrogation. A plant leader chaired it, and peppered people with questions. The supervisors who had inspected the dryer all said that it should be shut down. They argued that they could turn the dryer around in about a day if they could empty it first. If, on the other hand, the belt slipped off with the dryer full, it would take days to clean it out. After hearing this very consistent recommendation, the plant leader said that they were in an era of calculated business risks. Therefore, they should try to keep running until the other dryer came back on line, hopefully at the end of the day. However, the plant leader made no attempt to actually determine the risk and had not inspected the dryer. It appeared the decision was made before the meeting.

In the corridor, immediately following the meeting, I asked the plant leader about the role of the supervisors in operational decisions. I was told that they were expected to make decisions because it helps their development. When I probed a little further, the plant leader continued that they shouldn't make the big decisions. Several weeks later I asked a supervisor about the same meeting. He remembered it vividly and commented that he felt so undermined and under-valued he wondered why he bothered coming to work.

We can contrast this with a larger crisis in area ‘A’ at Wideplant. One weekend, they cleared a blocked waste pipe. Because of an error, the mixture of cleaning products and gunk from the blockage was sent to a tank containing a million pounds of waste which was intended for incineration, instead of to the waste treatment plant. However, the incinerator could not accept the cleaning products and the treatment plant could not accept a million pounds of concentrated waste. Furthermore, because the tank was a buffer between the plant and the incinerator, and the incinerator was having operating difficulties because of this problem, it looked like they might have to bring down the plant for lack of waste storage capacity. A number of complex issues and options were on the table at the tensest meeting of the study, which was held by a mixture of engineers, day points and facilitators from area ‘A’, area ‘B-C’, the incinerator, and elsewhere on the site. Rather than participate actively in the meeting, the coordinator listened and asked occasional questions. He did not suggest any solutions. He claimed in a follow-up meeting later that week that his career was on the line, though that was probably an exaggeration. If they had to dispose of the material off site, or stop production, it would cost hundreds of thousands of dollars. There were no obvious solutions, though a number were being advocated, including putting product tanks into waste service, sending material to be analyzed, and running experiments.

To the amazement of most people in the room, the production coordinator stood up at 10:28 to go to a weekly meeting with the business manager. When he did, people asked him what he wanted them to do. They clearly expected that he would make the final decision after they finished debating. He replied that it was their plant, and he was sure they’d make the best decision. When I asked him later, he explained that he was very worried about the material in the tank. However, that wasn’t the issue. He felt that the plant belonged to the people who worked the process, and he had to trust the people he worked with. He maintained that stance for the entire week, listening very carefully to the issues as they were discussed and debated, and as about two years’ worth of intra-organizational conflicts and recriminations were worked through, until a viable solution emerged.1

1 In particular, the incinerator was the poor stepchild on the site, and was perpetually starved of capital. Furthermore, one or two of the engineers felt they had been taken for granted by the other production units for too many years. They decided to exercise their new-found power by refusing to pursue some sensible options that would require them to do extra work.
From the above example, it would be easy to conclude that Highplant management was pre-emptive of the production employees and supervision, and Wideplant management was completely trusting. The reality was much more complex. The Wideplant controllers consistently told me they had the power to make any decisions they wanted, but only so long as they made the right decision. That was, they did not feel they had any real power at all. Autonomy from management was predicated on adopting management's thought processes and values. There was a clear basis for their statements. Often, in the morning meeting, they would be asked to account for a particular decision. If that decision was poor, they would be told off. For example, one day process 'A' was having operational difficulties and the inventory of intermediate product was low. The controllers in area 'B-C' decided to reduce production rates so they wouldn't draw the inventory down so quickly and risk a shutdown, which would mean a lot of extra work. Area management told them that they had erred. They should have drawn the level down much more quickly and then cut rates more radically. That way, in the unlikely event that process 'A' fixed its problems, they wouldn't lose production.

Similarly, in process 'A' at Wideplant, they had big problems with ice in the plant. In particular, because of leaking steam tracing, they had an icicle that was six floors high at one point. Also, because of exercises to thaw things with steam hoses, they had many ice rinks of frozen condensate in the plant. It was obvious to anyone in the building that these should have been eliminated. However, nothing happened until the production coordinator made a strong comment about the ice (once for the rinks and once for the icicle) at the morning meeting. By the end of that shift, people had started to work on the problems.

These four cases illustrate the true nature of power at both plants. People could do whatever they liked, but only as long as they remained within the boundaries created by those who really had the power, the production leaders. At Wideplant, the boundaries were significantly more spacious than at Highplant.

Wideplant employees who identified with management's values were rewarded handsomely so long as they could take initiative and articulate their interests in a way management would see as beneficial. One conscientious person was interested in computers, so he was trained in the design of control systems. Another high performer was interested in vibrations, so he was apprenticed to the site vibrations expert for a period. A third had a son in the baseball finals, and his transition from days to shift was moved for a month so he could attend the games. In contrast, a number of lower-performers complained to me that they weren't given these sorts of opportunities, even though a literal reading of management's rhetoric would make it seem like a right. There were only a limited number of such opportunities available, and those who had internalized the value system knew how to spot them, or create them, in an entrepreneurial way, and would be rewarded when they tried.

However, there was very little leeway outside of management's interest. A fifth case illustrates the point well. One night, because of a valving error, area 'C' at Wideplant had a huge spill. It was not clear at the time whether the government was going to press charges, but if so, they would have fallen principally on the controllers, who bear much more responsibility in a self-managed organization than in a traditional one. About a week before, the personnel facilitator for area 'B-C' had sent out a memo saying that one of the other plants on the site had four vacancies for controllers and that anyone who was interested should e-mail a reply. Because the transfer was from one operations job to another, the union posting rules did not apply, as they would if people wanted to go from operations to maintenance. Therefore, the move was at the discretion of management. Everyone on the crew which had the spill sent off a note.

I asked the production coordinator about this. He said the first thing he did was to ask those people who were "really interested" to send another note. Then he said that they would
consider allowing people to move if they had

a real career interest in going up to (the other area). We aren’t interested in
people who want to go up because it is better work conditions, or safer, or
something. We need a clear expression that they’d like to do something else.
Let’s face it, who wouldn’t want to go up there. It is easier work in a safer and
cleaner environment. The worst thing that can happen is you drop something on
your foot. But last Spring, when (other area) looked like being shut down, none
of them would have applied.

When I pushed harder he said:

It’s not a problem. In essence, it is an opportunity for us to talk to people about
their interests. Career interests is the key. The hard thing is to work out
whether those career interests are legitimate. (940215).

In other words, a “real career interest” would be needed to make the move, and the
criteria for determining what was a “real career interest” would be determined exclusively by
management.

The third Wideplant coordinator made the boundaries extremely wide. He took the job
two years before retiring and committed himself to not learning about the technology of the
process because he felt he couldn’t contribute at all. He also had a very hands-off style with
his direct reports. Over the two years, the supervisors taught themselves how to work as a
team and, by the time the new production coordinator arrived, they were almost able to run the
plant by themselves. However, the controllers complained about the lack of leadership.

The other place where this lack of tolerance was evident was in the relationship
between management and the union, particularly around the management of the worker-
management joint health and safety committee. We will see in chapter 12 that the committee,
which threatened management’s control over the workplace, was a constant source of irritation
to management.

The power of the production employees

So how much power did the production employees really have? Particularly, at
Wideplant, did they have none, as they claimed, as much as they wanted, as the strategy
dictated, or something in between? If so, where did it come from? The real power of the
Wideplant controllers came from two sources. First, Wideplant management emphasized
constantly that hierarchy was bad and that they were trying to eliminate it. This meant that,
irrespective of management behavior, the controllers always had a rhetorical basis for any
claim they wished to make against management. Second, the controllers simply had much
better access to management, so they had many more opportunities to attempt to influence
management’s behavior.

It is easy to see management’s rhetoric. Consider five examples. First, part way
through the study, management experimented with a new way of conducting conversations,
called triads. These were meant to overcome position-based power, whether as a result of
hierarchical position or expertise. The essential idea was that people with asymmetrical
power would have conversations in groups of three instead of two, so that no one person could be
dominant. It didn’t appear to last very long, but it was an attempt. Second, statements about
the evil of hierarchy would also turn up in most memoranda about the change effort. Third,
when the 'Compound' business manager had a transparency of an area organizational chart made up for presentation to a corporate visitor, he put himself on the bottom and the controllers and mechanical trades on the top. Fourth, the locations of people's offices are an indicator. At Widesite, there is an obvious location for the site manager's office, a large room with a stunning view of park-like area beyond the plant gate. Rather than make this his office, the site manager turned it into a conference room. His office was on the other side of the building with a view of a brick wall. The Wideplant business manager similarly wanted the plant coordinators to move their offices into the main building with the other managers and the central engineering group, as was the case at Highplant. The plant coordinators refused, however, saying that it was more important that they be near the controllers and facilitators. The business manager agreed and opened up a second office in one of the process buildings so he could work there if he needed to spend time with the plant coordinators or any of the area engineers. Finally, in what was one of the sincerest efforts I saw, the business leader was conducting an investigation into a near-miss event, where a steam hose flew off its mount and nearly hit someone. In his conduct of the investigation, he was extremely careful to explain absolutely everything that was going on to everyone present, and to ensure that the controllers participated in a way so that they didn't feel threatened. Notwithstanding the last example, these could all be dismissed as simply rhetorical claims. Triads will only diffuse positional power if the power is there in the first place. Those at the top of the pyramid have the power to write the memos, locate their offices, or redesign the organizational chart. Even in the last case, the business manager had a habit of being sincere and open until people said the wrong thing, and then pouncing like a tiger.

However, this rhetoric created an organizational space for those at the bottom of the pyramid to influence actions. For example, on my first day at Widesite, after my introductory meeting with the site manager, he walked me to the business manager's office. The business manager was sitting talking to one of the controllers who had come to discuss a grievance from the area. The controller did not hesitate to share it with the site manager and me, a total stranger. Similarly, when the area 'B-C' plant coordinator retired, a group of employees went, uninvited, to the business manager with three lists of names: those candidates they preferred, those they would tolerate, and those they would not accept, along with detailed reasons (couched in terms of the plant's human resources strategy) for their choices. The new manager was appointed from the first list.

In addition to having rights to access, the routine organization of work guaranteed much more contact with management. None of the Highplant production workers who worked shift attended the morning meeting or participated in projects (unless they were brought off shift). Of those who worked days, only one or two ever dared speak at the morning meeting. The shift supervisors, let alone the operators, only saw the plant leader one week a month. The Highplant day supervisors would interact with the crews through the shift supervisor, whose office was outside the control room, so they were much less likely to walk into the control room. They rarely had a need to talk to an individual operator. Finally, the plant leaders had their offices with the engineers and the business manager in another building about 400 yards away.

At Wideplant, in contrast, all four points attended every morning meeting, and the meeting was run by the panel operator. This meant that every panel-trained controller would see the supervision as a group about once every three day shifts (twice a month) when they chaired the morning meeting. Similarly, because all the facilitators and the plant coordinator worked a day schedule and had their offices in the same building as the control room, the controllers would see them in the corridors whenever they worked days. The supervision would drop into the control room to say hello or to discuss issues with individual controllers or crews every day or two. The majority of people at the morning meeting were controllers, and it became a public forum at which they would raise concerns. Because it was an official meeting,
issues raised there took on much greater significance than those raised privately in someone's office. (c.f. Goffman 1955). During the study, it was used this way twice. The week before I arrived on site, two controllers criticized the way the area was being managed. They felt there was too little direction, too much distracting activity (around point work and secondary skills), and therefore a risk of having an accident. On the other occasion, one crew of controllers felt they had been deprived of some overtime it should have been awarded. They were extremely upset about it and raised the issue the next time they worked a day shift.

**Trust**

As a broad generalization, managers at Highsite were fundamentally theory 'X' while those at Widesite were fundamentally theory 'Y' (McGregor 1960). That is, Highsite managers tended to assume that people were lazy, irresponsible, and needed to be watched constantly, while those at Widesite tended to assume that people -- with an appropriate context created by management -- were fundamentally hard-working and responsible. More to the point, while Highsite managers claimed they were trying to become 'theory Y', Widesite senior management would not tolerate theory 'X' managers. Many foreman went back to production work or were shown the gate when the 'facilitator' position was introduced.

This difference in management's attitudes to trust is illustrated clearly by the observations of a pair of Highsite operators. When they tried self-management, a group went to Wideplant to learn about it first. Their host had been the area 'B-C' plant coordinator. The Highplant group was led by the prior plant leader and plant specialist. The Highplant supervisors kept asking the Wideplant plant coordinator how he dealt with particular situations. He kept saying that he didn't; they were all up to the crew. When the Highplant plant leader didn't understand, his Wideplant counterpart told two stories.

The first story involved a controller whose wife called in the middle of the day because their well had broken. The plant coordinator sent him home to fix it (so he could get to the hardware store before it closed) and he returned when it was done. The Highplant plant leader wanted to know how they would handle the guy's pay (would they treat it as vacation, discretionary leave, etc. etc.). The Wideplant plant coordinator didn't understand the question and said, 'we just paid him'. The Highplant plant leader tried again asking how they'd fill in the time card. Eventually the Wideplant plant coordinator understood and said that if his well broke and he wasn't going to have any water, he'd just go home and fix it, and he wouldn't put it on his time card. So, why should the controller?

The second story involved a controller who was burgled. They hadn't been able to find any coverage (another controller to do his job), but they told him to take time off to deal with the problem anyway. He completed the business quickly and came back to work. People asked him why he was there, and he said that he had done the errands. He asked whether they expected him to sit at home for the rest of the day when they were short-handed. The Highplant plant leader immediately said that no one in (Highsite's state) would do that. They would definitely have stayed away.²

² My own experience would suggest that not all Widesite controllers are as responsible as the one in the story.
The operators also gave a third example. It involved their attempt to buy a stereo so they could listen to music while working in the control room, something they had seen at Wideplant. Management said they couldn’t have one because there would be too much noise in the control room and people wouldn’t be able to communicate. They took it to the site manager. He told them “no” also. One day when the Wideplant plant coordinator was visiting the site, they told him what they had done and asked what they should do next. He was appalled that the site manager had even bothered to entertain the question. He should have better things to do with his time. He was more appalled that the site manager had told them “no”. As for the noise, he said that if he goes in the control room and it is too noisy, he turns down the radio. When he leaves, he turns it up again.

**Highplant operators didn’t trust supervision either**

The climate of low trust pervaded the Highplant organization. Production operators would frequently assert that the supervisors were liars. Shift supervisors had similar feelings about the plant specialist and the plant leaders. I’ll exemplify this more fully when I discuss attribution in chapter 10. However, this simple example will illustrate the point. I have selected it because it is so trivial that it almost ridiculous and yet it was a source of extensive discussion and tremendous anger. Site management decided that a large number of people would work in flame-proof ‘NOMEX’ clothing. It negotiated a contract for about $1,000,000 worth of clothing from a local supplier, and wanted to implement by a certain date. The supplier could only meet the deadline if people were restricted to blue and khaki. When they went to get fitted, some of the operators asked the salesperson about the other colors in the catalogue. The salesperson said that they could supply in all the colors, so one operator ordered red. Soon after, he received an e-mail from the plant leader who negotiated the contract saying that the salespeople had been wrong. The contract was only for blue or khaki. The operators’ immediate assumption was that the plant leader had lied, rather than the salesperson being mis-informed, and he accused him of as much.

**A counter example at Highplant**

I found one important counter-example at Highplant. It illustrates the tremendous difficulty of creating trust in an intrinsically untrusting environment. The story was told to me by an engineer who had just finished complaining that management trusts the engineers enormously on projects, but once the project is up and running, you just about need an act of Congress to change anything.

For the building ‘C’ modifications, the engineers wanted to go to a ‘single line’ operation for some components. That is, there would be only one unit in a given stage of the operation instead of the five or six they traditionally had in parallel. The operators were very concerned with this. The engineer estimated that if they had said, “we are the engineers, and this is what you need...”, it would have been a disaster.

Instead they talked with different group of operators about the old process, and found there were parts which were hopelessly inadequate.\(^3\) If there were similar problems in the

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\(^3\) Despite findings like this, many of the Highplant engineers believed -- at the time of the
new process, the operators' concerns would have been justified. At these meetings, they wrote down the concerns about the 'single line' and problems with the old process, and what they thought was causing them. They also listed the strengths of the old process. They sent the concerns to Wideplant and other 'single-line' plants and then visited with a group of operators to discuss the issues.

From these meetings, they constructed a list of best practices in 'compound' technology, and identified the three major technical problems with the old plant which had to be fixed before the operators would support the single line. By the time they returned, the operators were comfortable with the idea. However, trust was so low that the crews still weren't convinced. During design and construction, the engineers had the same arguments again with the other operators and mechanics. Slowly but surely the operators started to understand. But, they didn't accept it until startup when they found that they could modify the plant to deal with some of their lingering concerns, and that problems with another part of the plant were completely overshadowing their worries.

**Trust at Wideplant**

The above two sets of examples show that Highplant management didn't have a lot of trust in the operators and the operators had even less in the supervision. However, it is hard to show that there was more trust in either direction at Wideplant. Trust tends to be invisible, whereas non-trust tends to be apparent. There are plenty of examples of non-trust by operators of the Wideplant supervision. For example often when something untoward happened, I would ask a controller why he didn't call it an incident, have an investigation, and sort the mess out. Universally, the controllers would reply that that would be a really unwise thing to do. As soon as you do that, they said, you gave complete control over the event to management. Similarly, when a spill occurred in area 'B-C', many believed that management would not stand behind the controllers who were legally at risk, when in fact it did. Similarly, people could quickly point out all the contradictions in the tasks they had to do and their belief that management didn't care about the risks involved. Again, I will exemplify this with the discussion of the joint health and safety committee in chapter 12. In addition, many controllers claimed that management didn't trust them. As we saw above, many people felt they were only trusted to make correct decisions. If not, they would be reprimanded.

There are one or two examples of trusting behavior. We saw one of very trusting behavior by supervision: the area 'A' plant coordinator's comments to me in the management of the waste tank incident. He made a similar comment on another occasion, when the controller who was chairing his area environmental committee wasn't performing and a regulatory deadline was approaching rapidly. There are also examples in the other direction. When one of the businesses on site was threatened, everyone on site could see that site management was working really hard to save it. At Highplant, in contrast, operators expressed a constant fear of their jobs being part of the "great sucking sound" of jobs being moved to the third world.4

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4 In fact, the Wideplant jobs were at greater risk because Highplant had, in theory at least, a much lower marginal cost of production and higher reliability. The plant was newer and therefore much more efficient, more vertically integrated (with process B2), and its inputs were cheaper (because the U.S. has low taxes on petroleum and they didn't have to
While I cannot show the higher trust directly, I can show two things. First, Wideplant management was aware that trust was important, and that it had to be managed actively. For example, at one meeting during a dryer failure at Wideplant, a controller accused a facilitator of trying to make them work harder. The facilitator stopped the meeting and highlighted that the important thing that everyone there had to understand was that they were all here because they wanted to make 'compound' of the highest quality and the lowest cost, and that they had to all trust each other and use that as a starting point when they conversed. Second, there was much less need for trust at Wideplant because everyone had a much better idea of what was going on. Trust is only needed if the other person knows something you don't or has some other sort of potential advantage over you. At Wideplant, the information flowed much more freely and the power differentials were much lower.

In summary, we have seen in a number of ways that the supervisors at Highplant trusted the operators much less than their Wideplant counterparts, and that the Highplant operators trusted their supervisors much less than their Wideplant counterparts.

Control

As noted in chapter 5, control was the center-piece of the traditional operating strategy. This became codified as a cultural variable which was still strong at both sites at the time of the study. Widesite was trying to become less control oriented, and differences were visible, particularly when it came to trying to control events in the external environment.

Consider my research access. I began the study as an examination of the relationship between safety, energy, and environmental management in the corporation. In particular, I was interested in understanding how Transitech, which was reputedly very good at safety management and was claiming that "environmental management is just like safety management" and "energy management is just like safety management" was using its safety management experience to learn how to do energy and environmental management. At one point, this study almost became derailed when the Highsite manager became very worried that he had no control over my output and it hadn't occurred to him that I would be examining the site's environmental management. Despite our assurances and offer of right of review, he insisted that he felt too vulnerable. He clearly wanted (but could not have) control over the outcomes of the study or their dissemination. He eventually reduced his anxiety by insisting that the project be approved by a Vice President. In much the same way, my sponsor in the corporation described me as the most uncontrollable thing he had to deal with in his entire career. He terminated my access when the Vice President received a new portfolio in the corporate restructuring. In contrast, the site manager at Widesite delegated the access decisions to the Wideplant business manager. His only condition was that I was not permitted to write only about the good things on the site, because then it would be a waste of their resources in terms of what they would learn.

transport raw materials as far). In practice, because Wideplant was better managed, the marginal cost differential was less than it could have been.

5 Other researchers who have studied Transitech in a comparative context and employees of other companies in the chemical industry have noted this emphasis on control. For confidentiality reasons, these references remain uncited.
Attitudes to site security were similar. The Highplant operators were all quick to point out to me that the barbed wire on the fences pointed inward. That is, it was designed to keep people in, and not out. Similarly, the electronic gates locked automatically if there was a chemical release, fire, or other alarm. In contrast, it was very easy for just about anyone to walk in and out of Widesite. This physical artifact interacted with the cultural reality when the sites had the threat of a visit by 'Greenpeace'. There was a possibility of a visit at Highsite during my stay. At the weekly meeting of the managers, the site manager explained that this group was very radical. He said that they expect demonstrations, publicity, and possibly violence. He pointed out that they would be ready with stand-by statements about their pro-active policies around (a chemical), and so forth. Because Widesite manufactured (the chemical), it was visited once. A demonstrator walked through the main gate at shift change. He proceeded to climb the water tower and hang a big banner. After a while, the site manager went out to talk with him. He told him that it was probably quite dangerous to be up the tower, and that he had gotten his publicity, and that he respected his position, and he was free to leave whenever he wished. He refused to have the demonstrator arrested. The story made a very uneventful 30 seconds on the evening news.

This difference was also exemplified clearly in the internal operation of the plants. We see this in the selection process for the operators who were to go to help with the startup of a new greenfield plant in an exotic country. Because Wideplant was an afterthought, most of the people were already selected. The selectors wanted Wideplant to simply send a list of names. However, Wideplant management insisted that the selectors come up to the plant and conducted interviews, as they had in the U.S. This would protect them from disgruntled employees, and ensure the new plant knew what it was getting. The only constraints they put on the selection were that they had to take a mix of wagger and staff from areas A and B-C. In addition, there were some permutations and combinations which would have been difficult because of the way they eroded the skill mix, but they didn't come up. Management's basic premise was that if it would help develop a person, and they wanted to go, then they wouldn't stop them. At the end of the day, over dinner, they asked the selectors whom they wanted. They approved all but one person immediately. They had to check on one other because he had moved to another business unit. That group approved the person by 9:00 the next morning. The selectors were amazed. They recounted the story of how it had taken 4 months to negotiate its list of people who could go from one of the U.S. plants, and not much less from the others. My source refused to comment on why he thought it had taken so long, though he hinted. The behavior is certainly consistent with the control hypothesis and few others.6

The difference could also be seen by examining the conduct of the site managers when they were chairing meetings. At Highsite, it was unambiguous who was the site manager and his role in the meeting. The meeting would always be, at some level, a conversation between him and the rest of those assembled. In contrast, at Widesite, while the site manager was still dominant, he took a much lower profile, and tended to "teach" rather than "tell". The reader might like to note the similarities to the descriptions earlier in the chapter of the plant leaders managing crises.

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6 The only plausible rival hypothesis is that the plants feared massive skill erosion. That would support the argument in chapter 8 in a very scary way.
Conclusion

In this chapter we have discussed differences in stance. That is, differences in the way the people in the two plants stood in relation to each other, particularly when facing problems. As a general rule, people at Highplant were more interested in controlling one another, less trusting of one and other, and tended to resort to positional power to achieve what they wanted. In contrast, Wideplant was trying to empower its workers, build trust, and build self-reliance. However, it is important to note that, in absolute terms, Wideplant management still maintained a great amount of control.
10. The effects of stance and strategy. Impacts on the major organizational activities.

So, we have two sites with different strategies and structures, and, as a result, people who hold each other in a very different light. How does this affect performance? In chapter 7, I suggested that we could determine which plant was higher performing by answering five questions about the management of exceptions. These dealt with exception avoidance, exception containment to it doesn’t turn into an event, enacting the right exceptions, managing events, and learning. Skill differentials e.;plain, in part, differences in the plants’ abilities to avoid exceptions, or manage them once they are occurring. But, that is not all of the difference. In this chapter, I examine differences in the way many of the 12 activities described in chapter 1 were carried out. This provides indirect answers to some of the initial questions.

Before embarking on the comparison, six things need to be reiterated. First, it is important to note that routine activities, which correspond to the vast majority of the work done in the plants, are barely discussed. I focus principally on exception management because the technology was very sensitive to exceptions. Second, both of the plants were having extremely rough times throughout the study. Not only were they having tremendous difficulty keeping the processes on-line, but morale was extremely low. Therefore, the reader should note that the descriptions possibly represent people showing their worst sides. In calm times, the plants are probably happier and friendlier. Any differences in the size of the problems they faced can be attributed to historical differences in their management, however. Therefore, I am quite confident the comparisons are fair. Furthermore, behavior in the bad times, not the good, probably determines the organizations’ capacities for change, since that is when one group of people sees what another group is ‘really’ like. Third, comparative research casts important differences into stark relief. It makes no statements about the absolute performance of the plants. Fourth, as noted principally in chapter 4, the plants were extremely sensitive to exceptions. Only minor differences would be needed to create large performance differences. Fifth, when discussing the behavior of individuals, it is very easy to under-estimate the importance of the organizational processes which both selected that person for that particular position, and which reinforce certain behaviors. The argument here is about organizations, not about people. Finally, I talk about certain organizational behaviors in the context of particular activities, generally those are the activities where they were most important. Needless to say, these behaviors pervaded all activities.

The chapter is divided into four major sections. The first three represent distinctions made in chapter 1. In the first section I examine initiation of routine activities and event management activities. In the second section I examine the way the plants managed exceptions. In the third I compare the way they learnt from exceptions. In the final section I compare the morning meetings as a microcosm of the rest of the organizations’ behavior to show some of the ways these differences pervaded even the most routine activities.
Initiation of activities

Asking people to do things: Getting the almost routine things done

Unambiguously, the people at Highplant were better at getting mundane and routine jobs done. Once they decided to do something, the thing happened. Consider, for instance, the differences in the safety audits. After a period of erratic safety audits, Highplant management decided they were important, so they scheduled two per week. Everyone turned up at the appropriate time, and the audit was performed in the appropriate manner. (The qualitative differences between the audits will be discussed below). Similarly, all of the weekly and monthly inspections were performed on time. In contrast, the Wideplant safety audits tended to slide. A given crew had to schedule them sometime in a two day period, and some of the crews seemed to try extra hard to schedule them on the second day, and then get too busy to actually have them. It took me several weeks of trying before I could actually get on a couple of Wideplant audits. Either they would happen at a time radically different from the scheduled time (and I’d have something else planned), or more likely, they wouldn’t happen at all. Similarly with routine inspections. On one safety audit at Wideplant, we were meant to inspect the breathing air system for unpleasant non-emergency situations. Although these were meant to be inspected regularly, it was clear they hadn’t been looked at (nor used for that matter) for several years.

It is important to emphasize the high proportion of work that was mundane like these inspections. For most of it, the technology or routinized interactions would force it to be done. However, in the cases where there was nothing external forcing the behavior, both sites were constantly struggling. This was visible in their efforts to keep their process drawings up to date, to maintain an accurate installation and maintenance history of the equipment, and to ensure that the findings of their audits were actually implemented. Highplant was unambiguously better at these sorts of activities, but only in those cases where management had explicitly identified the issue and decided to act on it.

Deciding to do things: Discretionary initiation by the operators.

Given the incredible sensitivity of the technology, and the potential of problems to cascade through it, the motivation of people to get on top of problems as soon as they emerged should not be under-estimated. We saw, for example, that laziness or thoughtlessness by a mechanic who was installing a steam tracing line in area A at Wideplant (he didn’t bother to return the condensate to the condensate system, but let it flow to the air instead) led to a six-story high icicle within two days. That took the controllers several frigid shifts to clean up. It also caused tension within the controller group when one controller refused to do the clean-up work, claiming that this was not what he hired on to do. This meant that most of the work was done by the (much younger, female, and therefore less powerful) controller on the opposing shift. At least one controller from her crew, one from the same crew in area B-C, and a mechanic, spent a couple of hours each helping with the job.

Of course, the operators and mechanics had a lot of devices available to avoid taking the proactive steps needed to keep the plant at its peak. For example, at Wideplant, during one of their uncontrolled excursions in the amount of materials available, the crews suddenly became incapable of unloading more than four rail cars in a day, instead of the usual eight. The shunting never seemed to work quite properly. This meant the problem became worse and worse.
At one point, the plant was forced to store its rail cars on a public track in the town. Not only did they incur demurrage charges for the storage, but the customs office became very upset because the cars should have been cleared though customs and into the plant or shipped back across the border. At minimum, the controllers clearly were not trying very hard. I was told -- but by an unreliable source -- that there was a deliberate slowdown to force management to put on more overtime. (Overtime rates had been slashed during the previous six months and people were feeling the loss of income.) I could find no way to confirm this, though it is certainly plausible.

While some people at both plants sometimes had a habit of not making an effort when they should, there was one key difference in the way they did it, and in their motivation. At Wideplant, everyone was very conscientious about staying on top of the core production process. For example, the practice of letting problems slide to the next shift had been virtually eliminated. If it wasn't in the productive core, they tended to play out their frustrations, or simply lack of conscientiousness. One theoretically interesting example is that of the waste treatment plant, traditionally a low-power part of the organization, (see also Cebon 1992) but managed by Wideplant on Widesite. The plant engineer and I would often sit down and chat. In the process, there would invariably be a litany of frustrations about the impossibility of getting anyone to do anything right in the waste treatment facility. There were some near misses. The worst was probably a process upset caused by the panel operator neither monitoring the equipment closely enough nor responding the high pH alarms. The engineer came in to the control room on the way home, looked at the DCS screen, and asked why they were still adding base, when the acid had been neutralized since 10:00 a.m. A major bug kill, which would have shut down the site, was just a voided. However, I really understood the concern when I was coding the field notes at the end of the study and found that the engineer had made the same complaints about the management of the same unreliable meters, in the morning meeting, a year before.

At Wideplant, this behavior was generally restricted to peripheral activities, generally came from a lack of conscientiousness, and, compared to Highplant, was relatively rare. At Highplant, in contrast, there were problems in the productive core, and the behavior had a feeling of aggressive vindictiveness to it. In particular, the operators tended to assiduously avoid noticing equipment that needed to be repaired. They would leave that to their supervisors. They would simply walk past machines that were obviously leaking or having other problems. This would happen once every couple of weeks, normally on weekends. Similarly, during one start-up, the operators knew there was condensate in a system which had to be dry, and knew that a supervisor had seen it, and knew that the supervisor had forgotten to act on it. However, they went through the motions of a start-up and waited for the whole thing to crash. Undoubtedly, these behaviors cost a lot of productive time and damaged equipment. None of this would happen at Wideplant. I'm sure this was a major contributor to the constant repairs Highplant was doing during the study.

**Being asked to do things: The problem of competence.**

One of the main things that supervisors at Highplant did was to ask people to do things (while Wideplant controllers were expected to decide for themselves). Sometimes the job was unpleasant and most people would want to refuse it. There was a general consensus among the production workers that the one way to get the power to refuse was to get a reputation as a competent hard worker. As one of the mechanics put it:

The foreman always acts like you are trying to shirk, unless you are a person with a reputation for being a hard worker. (921110)
I asked a number of operators (about ten) if this was true for them too. They all said this was the case. A number added that this meant that people with reputations as bad workers would often be asked to do the dangerous jobs. Having a low level of power meant being exposed to more risk. One operator, who had a reputation for being one of the worst on the site, told me the following story. Earlier in the discussion, he had complained of the seeming irrelevance of some of the safety programs compared to the real risks people have to face (see also chapter 11).

It was the worst job on the entire plant site, and I always had to do it. The job was in the ... building and involved tightening some bolts on the flange on a calandria. The gasket would leak [very corrosive process fluid]. You had to wear a full (acid) suit and when you were doing the job, you would have to turn away to take a breath to avoid breathing the stuff. One day, some solid [process fluid] got behind my glasses and into my eye. My tears dissolved it and I got a burn. I got downstairs and washed it, but the eye got really red, so I went to medical. They had a big investigation planned, but they kept deferring it and deferring it. Eventually they had it on the Friday. Safety came down hard and said that no one should have to do that job, and so they welded the joint. After the big meeting, I went into the lunch room. I had a big bowl of food which I wanted to heat in the new microwave. Unfortunately, the microwave, (which had been bought at Walmart), had been tagged out because it hadn't been tested yet. Soon enough, a man in a white suit came and tested the machine for radiation. Of course it was O.K. If it wasn't, you wouldn't be able to have it in your home. 930427

These operators did not refuse to do the work because they believed -- which I did not see substantiated, but which I heard many times -- that the shift supervisor would "get you" if you refused to do a job. Quite simply, the shift supervisor had the power to administer rewards for things like suggestions and administer punishments for things like rule violations. If someone performed a task which was potentially dangerous or required a rule violation, they would be rewarded handsomely through the suggestion system. If they refused, the supervisor would follow them until they made a mistake, and then administer punishment.

Being asked to do things: The problem of attribution errors

In this section, I use attribution theory to combine differences in stance with problems of ambiguity, and look at cases like the one above in a different light. The relevant lesson from attribution theory (Nisbett and Ross 1980) is that, as the message transmitted to a listener gets more ambiguous, listeners tend to do two things, completely unconsciously. First, she (or he) tends to impose her own framing on the issue. That is, as ambiguity increases, the listener has,

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1 The area in which he was working was atypical, so we cannot conclude that the problems were this severe all over the site. When that area's business manager left the area a few years before the study, the number of reported incidents increased by a factor of about four and performance improved. This would seem to indicate that incidents were being suppressed and that people did not feel free to raise concerns. The prior business manager was one of the few senior managers on the site who was forced to retire when the corporation was re-engineered. However, since he had been promoted steadily for 30 or 40 years, his behavior was clearly tolerable for most of his career.

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and tends to use, more and more opportunities to impose her preconceptions of the speaker, the speaker’s motives, and the issue at hand on the message. Instead of substituting the missing information the speaker assumes she will, the listener inserts other information. Simultaneously, the listener can, and does, disregard more and more of the actual content of the speaker’s message. Second, if the listener wants to make sense of the message, she must fill a lot of the gaps -- the information the speaker assumes the listener has, but actually does not -- and ignore a lot of the contradictory information which makes the speaker’s message ambiguous. Given an apparent contradiction between the speaker’s message and her prior beliefs, she is likely to select her prior beliefs. One heuristic device which is often used to render a speaker’s message consistent with the listener’s world view is to attribute a motive to the speaker. This is the type of attribution error which was common in the plants.

If it weren’t for problems of politics, trust, and control (i.e. stance), this wouldn’t be such a big deal. However, if the listener doesn’t trust the speaker, is in a constant political fight with him, and believes that he is trying to control her, then the obvious attribution to make in any exchange is that the speaker is trying to coerce and control the listener, if the speaker has the power, or that the speaker is trying to malinger and avoid being controlled, if he doesn’t.

Given the highly political, non-trusting, control-oriented workplace at Highplant, it is no surprise that attribution errors were a huge problem there. For example, some Highplant operators thought that management was discouraging smoking, making people all wear the same color NOMEX, and requiring that beards be shaven because it was trying to dehumanize the workforce. Attribution errors were also a much bigger problem than at Wideplant because the Wideplant managers were aware of the potential for it (chapter 5). We saw this above with the facilitator who stopped the meeting at Wideplant to emphasize the importance of trust.

The following anecdote illustrates how bad the attribution problem was at Highplant. Soon after hearing the story about the operator with the corrosive powder burn to his eye, I started to learn about doing dangerous jobs. A picture emerged extremely rapidly because I had seen many of the brush strokes earlier in the study and people added extremely consistent ones. The ten-or-so operators I asked told essentially the same story. First, I would ask if they were ever asked to do jobs that were dangerous or violated procedures. They all would answer yes without hesitation. If I pushed harder, very few could give an example where a procedural violation was explicitly asked for. Then, I would ask what they did about it. They all said they had two choices. They could refuse to comply, but if they did, the supervisor would hound them until they slipped up. Then, they would be disciplined. Alternatively, they could do the work, which they tended to do. However, they were extremely careful about it. If they were hurt, they feared they would be disciplined extremely heavily, if not fired, because they would be violating procedures. As more than one of them put it, they were in a double bind, and either way, they risked “having their ass hung out on the line to dry.”

Given this extremely coherent story, I went to talk to the shift supervisors. The following summary comes from my interview with the supervisor with whom I had the best relationship. I started by asking whether demands to do unsafe work came down from above.

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2 I spoke to two of the other three. One presented a carefully reasoned discussion of the issues. He acknowledged that there are reasons why people might mis-attribute. In particular, he emphasized that the operators often don’t see the enormous care that goes into trying to making decisions if there is an unexpected risk. (A plant leader made the same comment to me spontaneously during an inspection of some equipment prior to a shut
The supervisor gave me an equivalent story of woe -- a history of powerful supervisors who would ask for things that couldn't be done safely and would punish you if you didn't get them done, or if you were caught out. This particular supervisor had spent a year on days (with a loss of overtime and a shift premium) for one supposed infraction and had been chastised by the plant leader for another, undoubtedly with a reduction in annual pay increment. The supervisor concluded the story by saying, "That's what it's like around here. They tell you to do things, but if something goes wrong, you have your rear hanging out to dry."

So far, the supervisor's and the operator's stories were extremely consistent. I then reversed the situation and asked whether the supervisor (who supervised many of the operators I had spoken to previously) ever asked the operators to do dangerous jobs. Here is the response. It is as close to a quote as I could manage:

There are situations where you have to say, 'This is what we need to do. Let's figure out a way to do it safely.' All they want to do is tell you 100 reasons why not to do it. This isn't true for all of them, but it is true for some. For some folks, for all unordinary things, they manage to find ways to not do the work.

I asked for a recent example. The supervisor said that [a piece of equipment] currently had a hole in it. This was the second time that it had happened, the first time was a few years prior. The hole was inside a distillation column, so they couldn't fix it without a total shutdown. To manage the problem until then, they decided to run the column at a higher operating pressure. They moved the BOP (best operating parameter, see chapter 3) from [level a] to [level b]. Now, the BOP was not set by a safety concern. The column was rated for much higher operating pressure. However, they got the best utility if they could operate at [level a]. So, they did the same this time as they did last time. They brought in an engineer and decided to raise the BOP. The operators all believed it was risking safety.

The reality is that the column can take the changes easily, and there are relief valves and interlocks in case we get it wrong. The operators think that whenever we choose to manage the business carefully, we are jeopardizing safety. But, in reality, we can only manage the business without jeopardizing safety.³ (supervisor's emphasis)

The supervisor gave another example involving steam leaks in process B2. The main stairs to the process have a 550 PSI steam line adjacent. Some time before a shutdown, a gasket blew out on a header, creating a large steam cloud. The operators barricaded off the area. The chances of the leak getting any worse were very low since the gasket had gone completely. The

³ This last sentence refers to the supervisors' reward system, where they lose pay increments if their supervisees get hurt.
operators complained that this was a safety risk which should be shut down. The supervisor disagreed. There were still two methods of egress; the back stairs and the ladder, as required in the code. It was just that getting in and out was not nearly as convenient as it was before. But, there is a big difference between convenience and safety.

The situation would sometimes be reversed. One Monday, the same supervisor told me with incredulity about the behavior of an operator how had been “detailing” on the weekend. A process had gone down. Just before they started it up again one of the operators discovered a leak in the reactor wall, which would vent poisonous gas until the reactor heated up. The supervisor was horrified that the detail operator had wanted to start up the process, with the operators wearing breathing gear, rather than know to leave it down. The supervisor expressed relief that they hadn’t had time to do so. When I discussed it with the operator, he said that he had been unsure what to do. In fact, he hadn’t wanted to start up the process at all because he thought it was unsafe, and couldn’t see any way of doing it without wearing breathing gear. However, he feared that if he made a decision to not start up, he would be told off. Therefore, he had deliberately stalled from 2:00 a.m. until 5:30 when the relieving supervisor arrived.

In summary, in many situations, when the operators didn’t completely understand the job, they decided it was dangerous. They then attributed a malicious motive to the supervisor. The supervisor could see the attribution error with ease. However, when talking about the commands which came from above, the supervisor made exactly the same attribution error as was made by the operators.

The hook

Of course, there is a hook. On occasions, the person higher up in the hierarchy actually did ask people to do unsafe things. There are two reasons for this. First, sometimes they didn’t understand all the subtleties of the job at hand and so they made an error. Second, sometimes people found themselves caught in conflicts and pressures between production and other objectives and decided to take a risk, especially if they thought the risk was low or they could scapegoat someone else if something went wrong. (See also, the description of the supervisor safety training in chapter 11). It is the existence of these bad requests which perpetuated the system, especially if the requestee felt she or he didn’t have recourse to object to the job, as is the case in an organization with high power asymmetries.

Non-initiation examples

There were also attribution problems at Wideplant, though not nearly to the same extent. In part, they were minimized because supervision had been trained to look for these problems and to intervene actively (the “blaming problem” as described in chapter 5, and exemplified by the supervisor who stopped a meeting to explain that everyone was there because they wanted to make product (chapter 9). Notwithstanding, two or three controllers would make apparently outlandish attribution errors at every possible opportunity. One was a union steward who was convinced that everything that happened on the site was designed by management to screw the workers out of money. Another was a controller who was convinced that every bad event was the result of someone’s sinister ulterior motive. For example, he saw

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4 Detailing was when an operator took on a foreman’s job for a shift because no foremen were available.
tremendous malice and malfeasance by one controller to explain why it was that one crew was overworked, and how that overworking resulted in the big spill they caused. It was untrue.

Perhaps the most important attribution error, from the point of view of change, was the complete lack of perception of the production workers at both plants, but particularly at Wideplant, of the power of those who supervised them. They had virtually no conception that these people were also highly constrained. For example, the controllers believed that the pressure on overtime was coming from the personnel facilitators, when it was really coming from the site manager another four levels up. This and similar issues meant that the controllers across the site universally hated their personnel facilitators, and the personnel facilitators didn’t all like their jobs the whole time. Similarly, the area A controllers believed that the production coordinator had the power to completely stop the rotations to days, when this was a basic element of the design of the work system, and was believed in strongly as a developmental tool. This lack of perception meant that the controllers were constantly blaming their supervision for things the supervision could not control.

The importance of attribution error for the rest of the chapter

Throughout the rest of the chapter, the reader will see tales of woe, particularly about the supposedly disrespectful behavior of Highplant management. Given the discussion in this section, it should be clear that Highplant management could easily have been behaving with integrity, but that the operators couldn’t see that. We will see this very clearly below when we see discussions of operator participation in decisions around flameproof clothing and the beards policy. In both places, the operators thought that management deliberately ignored them when, in all likelihood, management was told from above what the policies would be, and had its hand forced. However, the important thing to note is that, in the end, it doesn’t matter. If the end result is that the operators thought that management did not respect them (or worse), and that led to outcomes that were undesirable to all stakeholders, and no one acted to correct the errors, the subjective facts become more important than the objective ones in understanding the outcome.

Being asked to do things: The problem of capriciousness

There is one more important difference between the sites in the way tasks were initiated. Because of the power differentials between the production workers and the supervision at Highplant, the supervision had the ability to be capricious if they wanted. The two following matched examples show the way that capriciousness could lead to extra work (and therefore risk) for the production workers.

One Saturday, a piece of equipment needed defrosting at Highplant. The supervisor told the operators to defrost it. The panel operator asked if they should defrost some of the other equipment since the levels in the tanks were so low that they couldn't operate the rest of the building anyway. It seemed like a sensible idea and was usual practice. The supervisor said not to. A group of operators tried to persuade him. He insisted, saying that his ass was on the line for a whole lot of other reasons and that he didn’t want to risk it. The answer didn’t make any sense to the operators, but they were forced to accept it. Later in the day, I asked the supervisor why he didn’t want to do the defrost, and he said the didn’t want to, and that was his reason. The next day, bringing the building up, the operators found that one of the other pieces of equipment had clogged up while it was lying idle, so they were forced to defrost it anyway. This cost a day's production.
In contrast, area 'C' at Wideplant had a large defrosting operation that had to be performed every ten days or so. If a crew performed this operation, they both doubled their workload for the shift and increased the risk of getting hurt or spilling chemicals. The window for performing the operation was about three days long. That is, for the three days after the job 'should' be done, the operation became progressively harder, until it was very difficult. In the past, crews would keep deferring the operation back and forth until one unlucky crew was landed with the mess. At the time of the study, not only were the crews going ahead and performing the operation when it first needed to be done, but they would explicitly over-ride management directives to defer the clean-out (in an attempt to increase run life and therefore process efficiency) because they thought the facilitator who wanted to increase the run life (a former operator) did not understand the process well enough, and that it was a bad call.

A direct parallel can be found in equipment failures before scheduled shutdowns. While I was at Highplant, they had a shutdown of area B2 because they couldn't dispose of their waste (the disposing facility was having problems), the inventory was close to capacity, and it seemed like a good opportunity to do some maintenance. On the Friday before the Wednesday shutdown, the process went down. On the Saturday, when they tried to start up again, they found a gas leak. This took a couple of days to fix, so they weren't ready to start up again until the Monday night. However, because of operating problems elsewhere in the plant, their inventory was still close to capacity. If they had started up, they would have produced off-spec material for several hours, built inventory for a couple of hours, and then come down again. In addition to wasting a lot of materials, this choice required a tremendous amount of work. However, the plant specialist insisted that it be done.

According to one of the Wideplant managers, the same problem arose when he supervised area "B-C". Here, the controller decided it wasn't worth the effort and risk to start up and shut down again almost immediately. He decided to start the shutdown early and telephoned the plant coordinator at home to verify his decision.

Managing production exceptions

While the above sections discussed the ways in which differences in stance led to differences in the ways that routine tasks and exceptions were enacted and acted upon, and by whom, in this section, we examine the way it altered the way they were managed.

Implementation and problem solving: Helping each other out

The plants differed profoundly in the extent to which people helped each other out. At Highplant, there was a norm of helping only your 'buddies'. Sometimes, this norm was very strong. For example, the initial startup of one of the Highplant buildings was facilitated by some mechanics working with the operators assigned to the startup. After the day's work, the operators would help the mechanics do their day's work. Not only were these people working unpaid overtime, but this was probably illegal. Notwithstanding, buddyship rarely transcended racial lines, and often was not evident within a group, even if a given pair had worked together for ten years. Furthermore, many operators thought it was against the rules to help each other out. For example, one night an operator had to lockout and tagout process B2 in
its entirety for a shutdown, a job which involved several hundred locks and tags. His close friend was working in process B and his part of the plant was running smoothly. So, he spent six or seven hours helping his friend hang tags. He spent the next shift fishing for praise from his supervisor, in part -- he told me -- to prevent getting into trouble for deserting his post. His supervisor failed to provide the desired praise and told him, to his amazement, that his behavior was expected. It is important to note that this lack of cooperation was not a function of the work organization per se, but simply of group norms. Several operators in different parts of the site told me of supervisors in "the old days" who insisted that "no one takes a break unless we all take a break" and therefore forced people to help each other.

At Wideplant, all 12 crews had strong norms of teamwork. They would be helping each other out every shift or two, even for small jobs. Similarly, it was quite common for controllers from other buildings or the mechanics to help out a crew which was in trouble or to help out someone who had a particularly arduous job to do (like icicle removal). This helping was facilitated by the fact that for a number of years people had rotated through all ten jobs in the three process areas, rather than being assigned to just one process. Therefore, some of the older operators could help competently anywhere. As noted in chapter 5, some of this difference can be explained through regional cultural differences, but Wideplant management certainly encouraged teamwork, and Highplant management always rewarded individuals.

When combined with the differences in skill, we can see how such differences in teamwork would lead to dramatic differences in team-level competence at the two plants.


In this third section of the chapter, we examine the effect of stance differences on the abilities of the plants to learn from opportunities that arise.

The trust, power, and control differences worked together to create dramatically different airs of competitiveness between people in the plants. People at Highplant were much more competitive than those at Wideplant. We can see this in the differences in the plants' suggestion systems, where the Highplant operators saw themselves in competition with the engineers and the Wideplant controllers did not. Each plant claimed it would reward innovative suggestions from production-level personnel. While production workers at both sites complained that their ideas were ripped off by the engineers, or that they weren't listened to, I could see that it was a minor irritation to the Wideplant controllers and a major source of anger for the Highplant operators and mechanics. At Wideplant, it appeared to me that most of the anger came from attribution errors made by the controllers. At Highplant, on the other hand, it appeared much more malicious.

This anger at Highplant can be seen by examining the performance of the suggestion system. In one area, operators and mechanical tradespeople would suggest changes and a committee of operators and engineers would evaluate them quarterly. In the other, the suggestions would go directly to the plant technical leader, who would decide what to do with them. Only one of the two previous plant technical leaders saw this as worthwhile. Of the 46

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5 Lockout and tagout is a procedure by which the operators physically isolate equipment which is going to be maintained. It will be discussed below.
open suggestions in November 1991, about 85% related to safety concerns. Nineteen of the 46 were still being evaluated (41%) (as opposed to having been rejected or accepted in the last time period, or being designed or implemented). Those being evaluated had been on the books for a mean time of 10.2 months. By April 1993, only 42 suggestions were on the books, but 20 were still being evaluated (48%), with a mean time on the books of 20.8 months.  

Early in the study, when I was talking to people about anything they wanted, (see chapter 2), I had a conversation with an operator about the suggestion system. I took the notes directly into a laptop computer and have cleaned them up a little.

A lot of times, they give you a bonus if you give them an idea that saves them a lot of money. If you don’t document it then an engineer will just take it and write it up six months later. Then, he’ll get the raise or the promotion. That happens to us a lot.

One idea was the dust scrubber. It had spray nozzles, which we had to go and dig out every two months. We sat and talked about it and came up with an idea. Bill wrote it up and sent it in to them. It was rejected. Six months later, the same engineer he gave it to came up with the same idea and was promoted. There was nothing we could do about it. Bill went and talked to him. He said he changed it, so it was his idea.

We messed up [a piece of equipment] so Ted wrote a suggestion up to put a ‘compound’ meter in the line so we’d know what concentration we were sending. And they put it in, but the engineer got the credit. Ted fought them for 2 yrs and got a little bit of money. But, that was because Charlie Jones, who was then the plant specialist, went to bat for him.

Back when I had just gotten here there was a guy named Bobby Murphy. He had kept copies of all the suggestions he made, in his locker. Every time some engineer would do some improvement in the area he would pull out his piece of paper and show the engineer how he had suggested it before. It didn’t do him any good. They didn’t give much compensation then. He just wanted recognition and they still wouldn’t give it.

As for now, if you go out there now and find a problem and fix it, they give you a gift certificate for $40. "Above and beyond" they call it. They give out a few. I got one for finding a leak on the vacuum jets. It isn’t the Plant leader who recommends you for them, it’s the first line supervisor. We make suggestions to the point where we make our jobs easier. We try to make as much money as we can for as little work as possible. (921107)

As a result, the suggestion system was a failure. The operators felt that it was more likely that an engineer would expropriate a good suggestion and garner a promotion, than that they would be rewarded themselves. This was especially true because they did not believe they had the technical skills to make a polished suggestion, just the basic idea for one. They felt so undermined by this whole process that they suggested only those changes which would make their jobs easier or safer. Once they reached the bottom of their list, they stopped

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6 In contrast, Kornbluh (1984) cites a Japanese petroleum refinery which received over 500 suggestions per year. Of these, the vast majority were efficiency-related.
making suggestions.

![Graph showing annual suggestion rate at Highplant]

**Figure 10.1 Annual suggestion rate at Highplant.**

(Number for 1993 has been extrapolated from five months' data.)

**Competitiveness and information**

The competitiveness between people at the bottom of the organization (for example operators and junior engineers) also pervaded the way people treated information. Early in the study I noted to a Highsite business manager that people didn't seem to give information to anyone who didn't need it. He pulled from his filing cabinet a cartoon of an organization chart with barbed wire around all the boxes. The caption read "foxhole management". He showed it to one of his plant leaders who was walking past. The plant leader laughed and asked for a copy.

I saw this attitude to information frequently. The following is a fairly typical example. The day after the semi-annual meeting of all the supervision (see chapter 4), an operator asked his shift supervisor if he had brought up the problems of manpower shortages on shift at the meeting. The supervisor said,

> We didn't discuss those sorts of things at this meeting. This was a meeting with all the production and all the mechanical people.

When the operator hinted strongly that he would like to know what they did talk about, the supervisor either didn't take the hint or chose to not respond. It is worth reiterating the observation in chapter 4 that the material they discussed at the meeting, particularly relating to the financial status of the business, was discussed at the weekly core group meeting at Wideplant and major news would be announced to the controllers at the morning meeting. However, to put it all in context, the readers should understand that some businesses in the corporation didn't even give their plant leaders access to their cost data until the late 1970's.

A second example involving competitiveness over information involved a controversy which raged over whether a design modification was affecting a piece of equipment. An engineer presented data to a meeting where he showed that the modified equipment had a
shorter mean time between failures than the unmodified equipment (a bad thing). He wanted to remove the modification. A debate ensued, with two operators claiming that the engineers didn’t know enough about the operation to claim the modification was causing the failures. The operators felt the correlation was spurious, and managed to persuade the group to conduct a set of observations of the equipment to try to understand why it was failing. A few days later, I was talking to one of the supervisors. I asked him about the folders on his bookshelf. He explained that these were his records of equipment failures. He pulled down one and showed me how he had documented every failure of the equipment in question for the previous two years. I asked if he planned to share the information with the operators who were conducting the investigation. "What, with that know it all? You must be joking."

Finally, competitiveness over information was also important between some of the production workers. Two examples illustrate this. First, one of the operators assisted with the design and the construction of the new facility. However, when he came back to shift, he refused to share any of his new knowledge with other operators. Instead, he chose to monopolize it. This made many of the others furious. Similarly, consider the conversation I had with one Highplant operator about the rotation period between the jobs within the crew. As noted above (chapter 4), the operators in the two plants spent different amounts of time on each job. Generally, the Wideplant operators spent one shift on each job, with some crews spending more and others spending less. People there discussed the optimal frequency of rotation in terms of a trade-off between the benefits of new eyes on a job and the risk of people simply passing problems on to the next person. At Highplant, operators spent longer on a job before rotating. When I discussed the idea of very rapid rotations with one of the operators at Highplant, he commented spontaneously that short rotations might be a good idea because that way, if the panel operator worked the field operator really hard, it wouldn’t be very long before the guy in the field would be working the panel, and could get back at him. Clearly, the two sites had differences in the relationship between operators.

*Routine learning: Feeling ignored*

The differences in stance between the two organizations meant that the Highplant production workers felt that they were ignored, while the Wideplant operators felt their input was valued, even if it was not always used. When I asked one Wideplant controller about providing input when so many things didn’t actually happen, he gave me a detailed description of the way one particular engineer asked for input on projects. (The particular engineer had gone so far as to produce 3-D color drawings of a major process expansion to make sure the controllers understood how the building would work.) While the other engineers were not so conscientious, they all saw the input of controllers as central to the quality of their work. Similarly, controller input was valued in other domains. Consider, for example, the work to bring a new material supply stream on line, as discussed in chapter five.

*Process hazards reviews*

The difference between the sites can be seen very clearly in the management of process hazards reviews, a routine task in which a team spends several months deconstructing a part of a process (on paper) to determine whether or not there are any risks that have not been identified before. I sat in for a day on a hazards review at Highplant. The one production operator on the team of about five or six sat in the corner and only answered questions when asked by the engineers. In contrast, at Wideplant, one of the senior engineers had taken a group of controllers and had put them through several hazards reviews so they could build expertise in the techniques. Some of them had been sitting on teams for about 10 years by the time of the
study. He then made sure that there were four controllers or mechanics on each team. The expectation was that the hazards reviews would become a true collaboration between the engineers and the controllers and mechanics.

**Safety audits**

Another place where this difference was clearly visible was in the conduct of safety audits. At Highplant the audits would be conducted by an operator, a mechanic or electrician, a supervisor, and a plant leader or the business manager. At Wideplant, they would be conducted by a controller, a mechanic or electrician, and a facilitator or the plant production coordinator. As I said above, the Wideplant audits had a habit of not happening, or happening after the scheduled time, so I didn’t attend as many of them as I attended at Highplant.

Notwithstanding, at Highplant, the pattern was very clear. First, nothing ever happened until the business manager or plant leader arrived. People were very half-hearted until then. Second, the plant leader or business manager found the majority of the audit items, and the supervisor found most of the rest. The operator or mechanic who was recording the audit items always found none, and the other operator or mechanic rarely found more than two or three items. Finally, everyone would look to the plant leader or business manager for cues as to what to look at. If the plant leader or business manager started to inspect the bottom of the chairs, everyone would inspect chairs. If they checked the fire extinguishers, everyone would do likewise, or possibly even go over and see what they had seen. The Wideplant audits had the same feel to them, with the member of supervision very much setting the agenda. However, the supervisors were always trying to turn the audit into a team effort and were constantly talking to the operators and mechanics to encourage them to start thinking for themselves. This appeared to work reasonably well. The supervisor still found a disproportionate amount of the audit items, but the whole process wasn’t nearly so asymmetrical and the issues were discussed throughout the audit.7

**Articulated complaints**

In addition to my observations, the operators and mechanics at Highplant would often talk about their feelings of being ignored. The following examples are drawn from a discussion I had with some mechanics while they were being fit-tested for a respirator.

The mechanics were really upset about having to wear NOMEX (flame-proof clothing). However, the thing which really made them angry was that they had had a committee which was ignored. The mechanical trainer (a mechanic who worked days to perform training functions) had been asked to review the policy and had done so. He brought in some engineers because he didn’t want to be seen to be acting alone. They worked through the issues and decided all the mechanics needed NOMEX but only some of the operators. By the time they were done, however, management decreed that everyone would wear NOMEX.8

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7 I suspect that one of the issues at both sites, but moreso at Highplant, was that the operators and mechanics feared getting their friends into trouble by finding problems.

8 Wideplant decided that only people who worked in area 'A' would have to wear NOMEX.
Similarly, management formed a committee on whether to ban beards because they affect respirator fit, and asked for people to volunteer. One mechanic was very interested and volunteered. However, by the time he was invited to his first meeting the decision had already been made. The mechanical trainer was on the same committee, but he wasn’t invited to a meeting until even later still.

These mechanics commented angrily on this tactic (as they saw it) to exclude them from real participation in decision making. Typical remarks included:

They decide and then get the lower level people involved. They hope the lower level people will agree with what they have already decided.

The same happened when they talked about creating a 'safety-professional' position. This would be an exempt job which is like [the training mechanic]'s. They were told by the business manager that they would conclude it wasn't needed. However, when they concluded they did need someone for the job, the issue was just dropped and no action was taken. (921110)

I asked what ideas were welcomed. They said that management welcomes ideas which save time and money and don't cost anything to implement. I asked how they felt about this situation. They said that they just accept it and go on with their work. One worker summarized:

You can't fight it for too long. (However) it gets frustrating if they ask you to do something and you work really hard at it and then you realize that they've already made up their minds.

The discussion during the fit testing continued in this vein for a while. After they had left, the mechanical trainer (who had introduced me to the mechanics and was administering the fit-tests) emphasized several times that these guys are crash hot and highly motivated mechanics. If you want to, you should hear the complainers some time.

Numerous discussions with operators produced similar stories.

*Exceptional learning: the conflict between stance and learning.*

Lockout and tagout was a procedure by which the operators physically isolated equipment which was going to be maintained. For various reasons, the Wideplant procedure was superior to that at Highplant. The Wideplant controllers would have well documented tagging lists to do particular jobs, and would operate all the locks with the same key. All the locks would be stored in a bucket with chains with which to attach them. By having a designated number of locks in each bucket, it was easy to check if the right number of locks and tags had been hung. In contrast, the Highsite procedure required that a different key be used for every lock in the tagging job. This meant that, for a large job, the operators had to work with about 300 different keys. In addition, the Highsite construction organization insisted on a higher standard of tagging (known as double-blocking and bleeding) which meant that for jobs which would use construction employees or contractors, the job would have to be tagged to a different standard.

The difference between the two procedures is much more than inconvenience. First,
Highplant also had tagging lists. However, when I watched operators hanging tags, they would pull out the list and sign it, as required by the procedure, but they would never use it. When I asked one operator why, he explained that the lists were not accurate enough for him to be able to trust them.

Second, a number of key people did not understand the procedure. This was illustrated very clearly by a meeting of supervisors one morning after the morning meeting to resolve a number of recent violations of the procedure. They anticipated more problems that day with two pieces of equipment that were down for maintenance. The equipment was joined by a pipe with a single valve in it. Both pieces of equipment had to be locked and tagged out for the maintenance jobs they wanted to perform. However, the people running the job knew they would want to bring up and test one piece of equipment before the other. They wanted to know how to tag out the system so they could do this. The central problem was that all the keys for a job had to go into a lock box, and the mechanics would lock it shut. The operators could not open the box until all the mechanics’ locks were removed, i.e. after both jobs were finished. Alternatively, if they tagged the equipment as two separate jobs, they risked opening up the valve between the two pieces of equipment, and therefore violating the integrity of the tagging on one job when they finished the other. They discussed this for a while before the plant leader thought to bring in the operator who wrote the procedure and was responsible for its implementation, from across the corridor. The operator came up with the obvious solution of putting two tags and locks on the valve, one for each job, something he had clearly thought through before. The locks and tags for the two jobs could then go in separate boxes and they could remove one tag when one job was finished and not risk having the valve opened on the other job. This had been suggested twice earlier. The point here is simply that either the procedure was too complicated, or the level of understanding of the procedure, among the supervision at least, did not appear to be high enough for satisfactory use of the procedure.

The third problem is the one which caused the most concern. Essentially, because of differences in the way locks, chains, and tagging lists were managed at the two sites, the Highplant procedure was much more complicated than that at Wideplant. In fact, it was so complicated that the Highplant operators were not confident they could carry out a big tagging job accurately, no matter how hard they tried. A big job was too big to keep in mind completely, so they would have to rely on the tagging lists. However, the tagging lists were not accurate enough. They tended to be constructed for generic jobs, not specific ones. Therefore, there was a good chance of error, and no way to check it reliably. As a result, the training mechanic had included in the mechanics’ training for the procedure a warning that because the operators were not confident, the mechanics should follow the protective clothing procedure religiously.

One day, the training mechanic was teaching the supervisors and engineers about the procedure (which had been implemented about a year earlier to replace one that did not require locks). When he had finished the formal presentation he told them about the implementation problems. Rapidly, the meeting devolved into a dialogue between him and one of the four plant leaders in the room. The plant leader argued that the training mechanic was wrong and that the new procedure was much safer than the old one. The training mechanic explained that this new procedure was simply too complicated. He then made a mistake and said, "If you wanted to sack someone, all you would have to do is go out into the field in a big job..." (clearly referring to the belief among the production personnel that supervision would look for errors by the unfavored and punish them.) The plant leader then became very upset and resented the suggestion that they would ever try to sack someone. The training mechanic retracted the suggestion and pointed out that for one large job, they did the very best they could and then got the safety office to come down and audit it for them. Safety found ten errors.

The meeting sat pregnant, with the plant leader embarrassed and everyone else silent. The plant specialist then broke the stalemate by saying that the training mechanic was
right, and that they should move on now.

The organization's response to this 'learning' was very interesting. First, the procedure was not changed and no inquiry into the problem was opened up. That is, neither the operators' complaints, nor the inspection by the safety office, nor the event in the training meeting were constructed as 'incidents' to be investigated. It appears that it would have to wait for an exception which conformed with the organization's definition of an incident, i.e. someone getting hurt (see Chapter 11). Second, the training mechanic had to apologize to the plant leader. Third, there was a rumor that the training mechanic was no longer being considered for promotion to supervisor because he embarrassed a plant leader in public. That is, it would seem that the leadership of the organization was so concerned about maintaining the feeling of control over the situation that it failed to learn. Instead, it responded to the threat to its power.  

The trainer's fear that management would use the difficulties with the procedure to punish people was borne out in another area on the site shortly after. When a day operator came on one morning, he found that the night operator, who had tagged out a job, had made an error. He went to the shift supervisor, who stopped the job, and then corrected the tagging. The night operator was punished for making the error and the two mechanics were punished for not checking the job properly before starting work.

Morning meetings

In this final section of the chapter we examine differences in the way the two sites managed their morning meetings. Using a very crude quantitative analysis, I will illustrate many of the qualitative comparisons made above. The differences between morning meetings at the two sites were stark, to say the least. At a typical Highplant morning meeting there would be between 20 and 30 people in the room. The shift supervisor would be sitting at the head of the table. (One of the supervisors would even move the overhead projector if it was on the table, so he could sit at the head.) Around the table, in their particular seats, would be the area 'B-C' mechanical supervisor and electrical supervisor on one side, and the planning and scheduling supervisor on the other. At the foot of the table would be the area 'B-C' plant specialist. There were three more seats at the table, and they would be filled according to the following pecking order: the business manager or any senior engineers, the plant production leader, the plant mechanical leader, the mechanical planning and scheduling supervisor, the area 'A' production planning and scheduling supervisor, and finally, the other supervisors.

The bias toward area 'B-C' people at the table presumably had its origins in the fact that area 'B-C' had absorbed area 'A' and the new seating arrangements had not been worked out yet. For instance, half way through the study, people started to insist that the area 'A' plant specialist sit at the table. He refused for a while, but, after a few days, started to sit in...

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9 A plausible rival hypothesis is that the managers concerned believed that a non-supervisory employee did not have the intellectual capacity to see something that they had not. That is, there is a combination of groupthink which would support the supervisors' articulated view of the world (we will see in the next chapter, that many of the supervisors may well have agreed with the trainer and kept their mouths shut), and arrogance which would denigrate the view of the non-supervisory employees.
one of the seats next to the area 'B-C' planning and scheduling supervisor. Everyone else sat around the edge of the room. I was not able to discern any consistent pattern.

The Wideplant meetings provided a distinct contrast. With the exception of the panel controller/s who led the meeting from the head of the table, and the production coordinator who sat at the foot of the table, there was no assigned seating. Everyone just sat around the table. There were only about ten chairs, so generally three people at the area 'B-C' meeting had to stand or sit on tables. There was normally a spare seat or two for the area 'A' meeting. While the population at the Highplant meetings tended to fluctuate, that at the Wideplant meetings was very predictable. The area 'A' meeting was attended by the panel controller, the four day points (three at the end of the study), the four (three) facilitators, the area engineer, the waste treatment engineer, and the production coordinator, if they were on site. One day a week, the site environmental engineer would also attend to make sure the waste treatment plant was running properly. The area 'B-C' meeting was attended by the two panel controllers, the points and facilitators, four area engineers, and the production coordinator. One or two other people would turn up occasionally. The facilitators and engineers here were less religious than in area 'A' about coming to the meetings.

Nominally, all three meetings were very similar. They would begin with the person leading the meeting (the shift supervisor or panel controller) giving a report of the status of the plant. People would be free to comment or ask questions. Then, they would 'go around the table'. At Highplant they would go around the table and then around the room, so the supervisors would speak first (although the shift supervisor who had come from area 'A' would often go around the room once, alternating between people at the table and people on the outside). People around the room would then be free to bring up issues or questions they wanted discussed.

Most of the Highplant meetings were discussions between the people at the table, with limited participation by those around the edges. With one or two exceptions, the operators and mechanics never spoke. Things of substance were rarely discussed, except in the context of a crisis in the plant. Often, these discussions would be deferred until immediately after the meeting. These post-meeting meetings would be dominated by the plant leaders, the supervisors, and the plant engineers. In contrast, the Wideplant meetings were explicitly meant to be for the controllers, since they were the ones running the plant. The meetings had broader participation (the individual points would have to report on their responsibilities, so there was a much lower barrier to them speaking on other issues), more issues were discussed, and the discussion was more substantive. The only strictly held norm was that the production coordinator spoke last, and generally about broader issues. Only rarely would the production coordinator intervene actively in the running of the plant. That was assumed to be the job of the production controllers. However, difficult operations decisions were often discussed.

In the following tables, I examine nine randomly selected morning meetings from each of Highplant, Wideplant area 'A', and Wideplant area 'B-C'. I coded attendances, and the nature of the discussion. When I coded the discussion, I examined three variables. First, I examined the content of the discussion (operations, maintenance, shipping, personnel, training, laboratory, state of the business, wider issues beyond the plant, equipment, and irrelevancies). Second, I looked for statements of encouragement or sanctioning. Finally, I looked at the nature of people's comments. In particular, I created three categories: routine reports, questions or requests for action, or replies to questions. (It would be possible to categorize the comments much more finely, but the coding was done from my laptop notes of the meetings, rather than coding during the meetings themselves. The notes won't support a more nuanced coding scheme.) In the tables, I present the total number of comments for the nine meetings.
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<th>Engineer</th>
<th>Operator</th>
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Table 10.1 Content comparison of nine randomly selected morning meetings at Highplant -- totals.

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Table 10.2 Content comparison of nine randomly selected morning meetings at Wideplant area 'A' -- totals.
Table 10.3 Content comparison of nine randomly selected morning meetings at Wideplant area 'B-C' -- totals.

A cursory examination of the tables indicates a few things. First, we see immediately that the Wideplant meetings discussed a much broader range of issues than those at Highplant. At Highplant, it was generally restricted to operations, maintenance and the equipment, while that at Wideplant tended to discuss the "total business". This is consistent with their different aims.

Second, we can see that the total amount of conversation is greatest in the Area "A" meeting (the one with the smallest number of people), and that per person, the communication levels are much higher in area B-C at Wideplant than at Highplant.

Third, we can see that the participation at Wideplant is much broader. However, the controllers at Wideplant tend to restrict themselves to making reports. This is consistent with the idea that they don't really feel empowered, and therefore are shy to say anything that might get someone into trouble in front of management. (Consistent with this analysis, one day, all of area A management was at another meeting and the conversation between the controllers was much freer.)

Fourth, note the higher levels of communications with emotional content (sanctioning and encouragement) at Wideplant.

Fifth, note the much higher participation rates by Highplant plant leadership, even allowing for the fact that there were between none and three leaders at a Highplant meeting, versus none to one at Wideplant.

Sixth, the higher level of discussion of operations, relative to maintenance and equipment, at Wideplant seems to reflect the higher levels of reliability in the plant.

Seventh, 16/39 = 41% of Highplant cells have only one or two comments in them. Compare this to 33/56 = 58% in Wideplant area A and 25/40=62% in Wideplant area B-C. Even accounting for the lower talking rates of Wideplant area B-C, the greater frequency with which people ranged across topics suggests that the Wideplant meetings were less routinized.
Conclusion

We opened this chapter by re-posing five basic questions about plants' abilities to manage exceptions. In this chapter, we have seen that Highplant was much more likely to avoid exceptions that are predictable and can be eliminated through the routinization of activities. However, on all other scores, while far from perfect, Wideplant was a higher performer. Of particular concern for the safe management of the plants was Highplant's habit of enacting the wrong events through attribution errors, and not enacting the right ones, as people worked to maintain power relations. In particular, it appears that the attribution problems, when combined with the system of power relations, were leading to many people exposing themselves to much higher levels of risk than were necessary. Similarly, the cases of the lockout and tagout procedure and the suggestion system would seem to indicate that management's and engineer's efforts to maintain their stance and hold onto ownership of the plant were leading to the squandering of many learning opportunities.
11. Three ways of knowing and their behavioral implications

While in the last chapter, we examined the effect of stance and strategy on the way people acted, in this chapter, we examine their impact on the way they thought (or appeared to think). In the first half of the chapter we'll lay out the three different ways of knowing. Since two of them are complementary -- that is, they are used together -- these three ways of knowing will collapse into two modes of rationality, which I will label as "practical" and 'formal/accretive". Both modes were evident at both plants. However, the mix in usage varied dramatically. I will argue and demonstrate that people's thinking was essentially practical at Wideplant and formal/accretive at Wideplant, at many levels in the organization. While Highplant's performance suffered from too much formal/accretive behavior, Wideplant's suffered from too much inappropriate practical behavior.

Let us start with the basic idea (from chapter 1) that all knowledge can be understood as a network of proposition schemas linking image schemas, as represented in figure 11.1.

![Figure 11.1. A proposition schema linking two image schemas.](image)

The reader will remember that I described all action as a combination of sense-making, problem-solving, and implementation, and that each of these could be seen as the task of filling in one or more "blanks" in the above diagram. However, we also saw that each of these, in turn, could be broken down into further sense-making, problem-solving, and implementation activities. If the organization is to actually achieve anything, it cannot afford to have its participants lost in a void of infinite regress, incapable of doing anything, because they find themselves swirling around an ever-expanding vortex of sense-making, problem-solving, and implementation for smaller and smaller activities. In the end, people have to "know".

In the plants, I observed that there were three fundamentally different ways that people knew what to do, or what something meant. The first accorded with what we normally think of as "knowing". People would analyze the situation and tie that analysis to some beliefs about the world. That is, their actions would be consistent with their beliefs about various image schemas and the propositions linking them. On the basis of those beliefs, they would act. So, for example, I observed a Highsite mechanic observing a diesel water pump misbehaving in a particular way. On the basis of his observations, he concluded that the air distributor needed to be overhauled. I will call this way of knowing "practical rationality" (after Weber)(see Scott 1992). To ensure an appropriate amount of practical rationality, organizations hire educated people, and then train them further. This is the sort of rationality management was striving for at Wideplant. If people had true knowledge of the total business and an appropriate set of principles, they would be able to determine the appropriate way to act, without supervision telling them what to do.

Let's suppose management asked a practically rational person to minimize the number
of accidents. Such a person would develop a theory of accidents. If the theory looked something like Perrow’s theory of normal accidents (Perrow 1984), it would involve consideration of the way various technological and interpersonal systems interact when accidents occur. On the basis of that theory, the person would derive a set of principles which would guide action. For example, he or she might decide that people should make sure they are concentrating before performing important tasks. Alternatively, he or she might conclude that it is important for people to remain cognitively engaged, so systems should not be designed to be "idiot-proof". ¹ We will see in chapter 14 that Wideplant management decided that one of its accidents occurred because the total organizational system was overloaded. Similarly, Highplant managers observed that accidents often occurred when things were "not quite right". Therefore, they instructed people to stop and look around if things didn't feel as they should.

The second form of rationality I observed, I will call "Formal" rationality (again, after Weber). In this case, a person doesn't do what they think is right. Instead, they do what those who have power over them say is right. "Mine is not to reason why, mine is but to do or die." Formal rationality is vital to any large organization. It is an extremely efficient way of accumulating and transmitting knowledge. It provides the basis for a lot of training and indoctrination. By far the most obvious form of formal rationality in the two plants was through the procedures. Both sites had a hierarchy of procedures including "detail procedures, supporting procedures, and level-of-the manual procedures". With the procedures, it didn't matter what the individual thought was going on; they were expected to behave as if they believed the procedure was true (though they often had to understand what was going on to understand the procedure).

The key here is that the thought processes or categories are given to the individual concerned by those with power and that rational action comes through uncritical conformity. Those thought processes and categories may be written down, as with operating procedures, or they may be learned, as with norms or most other forms of routinization, or they may be handed out summarily, as in a supervisor using his or her power to tell someone what to do.

The advantage and disadvantage of formal rationality is that the person who is exercising it doesn't have to think. The advantage in not thinking is that a huge amount of organizational knowledge and experience can be codified and carried out reliably without the person having to re-derive it the whole time. That is, formal rationality is an extremely efficient way of getting people to appear practically rational. However, there is no reason to assume that something which is formally rational is also practically rational. If the two do not coincide, the person, while doing what is expected, may well be doing something which doesn't look terribly intelligent from the outside.

If asked to prevent accidents, a formally rational person would ask management how to approach the problem. When management said that accidents are minimized when people think about safety, these people would develop a set of activities to make people think about safety. At Highplant, for instance, they had "safety meetings" to discuss latch-key children and killer bees, they had competitions where people guessed the number of band-aids in a box or the number of safety errors in a picture, and every year they inspected the microwave in the kitchen to make sure the cord hadn't frayed and all the chairs to make sure they weren't breaking. None of these have any obvious logical connection to avoiding industrial accidents, except through some sort of imposed proposition about the relationship between "safety

¹ The first example comes from a Transitech plant near Widesite. The second example comes from a Flecsoco site discussed in Cebon (1993).
awareness" (very broadly defined) and accident rates, which presumably motivated the organizers of these activities.  

The mere existence of proceduralized systems created a context for people to act. For instance, the Highsite site manager stimulated the diversity program by making the various managers sit in a room and tell each other what they were doing. Similarly, a Highplant supervisor exploited the existence of the drug and alcohol program to intervene with a problem employee. Finally, a regulation on mandated training stimulated action where there had been little before, in one of the plants.

Ultimately, the distinction between formal and practical rationality at both a local and a global level, disappears. For example, Wideplant management attempted to give people appropriate cognitive categories by teaching them the appropriate "principles" by which they should understand the business and their tasks. The act of giving was a formally rational process in which people were told how to understand the world. Until someone actually believed the principles, using them would be a formally rational act. As soon as they believed them, the behavior would become both formally and practically rational. In general, we expect this will be the case. People will generally believe what their bosses would like them to believe. That is, they will have been socialized into the same global and organizational cultures as their bosses. At a global level, all knowledge is, in part, socially constructed. As such, the categories we use to understand the world are a function of our history which, in turn, reflects power relations. Therefore, our current practical rationality is, in part, a function of past power relations. However, practical rationality is always pragmatic. If it ceases to work effectively, it can be rejected. Formal rationality cannot.

Knowledge by accretion is an important accompaniment to formal rationality. If someone is practically rational, they have a set of tools they can use to explain the events in their lives. Those events will either correspond to a set of categories and the relationships between them, or they won't. If they don't correspond, and the person is wholly rational, he or she will change the categories and relationships so they do.  

A system of formal rationality, however, doesn't make any claim to completeness or consistency. If an event occurs, and we saw in chapter 3 that this is one of the dominant features of chemical plants, people need to act. Perhaps the event will correspond to people's prior formal rational systems. In that case, the event will be analyzable (Perrow 1967) and people will manage it effectively. That is, when they act, the problem will go away.

If, however, the event does not correspond to their formal rational system, they have a problem. Since a formally rational system doesn't give them the power to change their worldview, they have to understand the event as some sort of special case. That is, knowledge by accretion corresponds to the set of solutions to problems faced by the organization which enable people to make sense of their idiosyncratic history.

People who know by accretion would avoid accidents in a third way. They would look

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2 Obviously, the total safety program at the site transcended these few examples. As we saw above, for instance, extensive resources were invested to ensure that the technical systems had integrity and were protected by multiple safety devices.

3 We know, of course, that people are not wholly rational, so that the categories do not change nearly that easily. In fact, they tend to be very rigid (Bartunek 1988). Furthermore, people don't have coherent sets of categories (Lakoff 1987).
at the history of accidents at the site, and would design systems to avoid repetitions of those accidents. They would not consider the probability of that accident occurring. Instead, they would act as if they believed that a recurrence of that particular accident is more probable than many alternative accidents.\(^4\) Neither would they consider the possibility of other similar, but not identical, accidents occurring. Nor would they consider the possibility of completely different accidents with similar causal origins. In other words, there would be no attempt at generalization.

Consider the following example. While performing some welding inside a tank at Highplant, a contractor discovered that an underground pipe to the tank contained flammable liquid. The pipe was part of the fire-fighting system. The check-valve, which was supposed to prevent material from the tank getting into the fire system, didn’t work at low pressure. Therefore, the material seeped from the tank into the fire system when the tank was almost empty. This worried Highplant management, which was thinking practically. In their particular tank, the volumes were small and the solution was dilute. However, they realized that many tanks in the corporation are connected to fire lines, and there was a risk of some other tank being less fortunate. They wanted to alert a wide audience. The site safety officer, on the other hand, reasoned accretively that this was no big deal. The tank was empty, and it was a very dilute mixture. Therefore, they should treat it as a very minor incident.

**Ways of knowing and action**

Given that the vast majority of action in a chemical plant is highly routinized, and that Wideplant management insisted that people follow procedures religiously, what do I mean when I say that rationality at Highplant was fundamentally formal/accretive while that at Wideplant was fundamentally practical?

As we saw in chapter 1, action in the organizations can be broken down into 10 fundamental activities: initiation, sense-making, problem-solving, and implementation for both exceptional production and exceptional learning problems, and implementation for routine production and learning problems. We saw in chapter 8 that people at Wideplant tended to have higher levels of skill. We could recast that argument here to say that they had a higher capacity to invoke practically rational means, as appropriate, in the course of routine implementation, so long as that action didn’t violate the boundaries set by the procedures.\(^5\) Similarly, we can recast the discussion of initiation in chapter 10 to say that people at Highplant were much more likely to wait to be told to do something, than those at Wideplant. An aim of this chapter then is to examine implementation, sense-making, and, problem-solving.

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\(^4\) It is worth noting that in a system with prominent power relations, the political consequences of an accident recurring can be so great that people simply cannot afford a recurrence, irrespective of the probability. Furthermore, in very complex systems, it is very hard to determine the probability of an accident recurring (Perrow 1984). Both of these observations make it more sensible to avoid recurrence of a particular accident than it would first appear.

\(^5\) The procedures were a far from complete statement of what needed to be done to run the plant. However, in the context of this discussion, as noted elsewhere, it is noteworthy that those at Highplant were significantly longer and more detailed than those at Wideplant.
activities for events.

Implementation

This can be dealt with very quickly, so I will discuss it first. The expectation at both sites was that implementation behavior should be formally rational. While it was perfectly appropriate to be skillful in the context of the procedures, people were expected to follow procedures religiously. If they thought the procedure was wrong, they were expected to stop work. This was true up to the plant coordinator/plant leader level. We will see in chapter 17 that both of the Wideplant production coordinators were criticized for not following procedures in the conduct of accident investigations. In area A, the criticism came from the union; in area B-C, it came from the facilitators.

Sense-making

As noted in chapter 1, sense-making is the process of determining the logical relationship between a current outcome and the causal process which led to it (figure 11.2). In this section, I will show that management tried to teach people within the plants to make sense of their worlds in these two different ways (by direct teaching and through their actions). Then I will show that the sense-making was different in the plants.

Figure 11.2. The situation before sense-making

Lessons from management

I attended safety training meetings for first-line supervision (supervisors and facilitators) at the two sites. The meetings were held for slightly different reasons. At Highplant, management felt it wanted to re-emphasize the importance of effective safety management. At Widesite, a legal requirement was involved. As a result, the Widesite
meeting contained much more formal learning (e.g. of regulations, laws, etc.). A senior manager from each site attended each meeting and gave a speech to open it.6

The Highsite meeting began with a (supposedly true) story about Harvey the mechanic who died when he was sprayed with Hydrogen Cyanide. The message of the story was that Harvey died because seven procedural violations occurred. Although none was important by itself, these violations were fatal in combination. This message of enforcing compliance with procedures pervaded the day. For example, in the section on "Standards for Excellence", the instructor listed the following as the management tools available to supervisors:

1. Know the standards for safety management.
2. Define those standards.
3. Communicate those standards.
4. Enforce those standards.
5. Be consistent. -- Discipline people after three or four events.
6. Audit people's work, whenever it is required and whenever you walk into a process area.
7. Make appropriate corrections and have your expectations known.

Consistent with this, the designers of the workshop sent a questionnaire to the supervisors in advance, asking them what they would like to learn about. One of the clear messages that came back was that supervisors were having tremendous difficulty getting their bosses to make it easy for them to enforce safety requirements. For example, they felt they were shouldering conflicts between production and safety. A number of supervisors also brought up these conflicts during the discussion sections of the meeting. One said,

"If they [the plant leaders] make a decision, and it's a bad one, you're caught. If you make a wave, they'll give you a bad rating [annual performance appraisal]. However, if you don't, you live with the mistake of something being done because it is cheap. People are afraid to stand up for what they believe is right."7

However, despite these pleas, these problems were not addressed in the design of the meeting. This behavior is consistent with the idea in a formal logic system that those who define the procedures through their power don't have to be accountable for them to people who are less powerful than they are.

6 At Widesite, the senior manager gave the opening speech. At Highsite, the site manager arrived late and the introductory speech was given by someone else. However, since the story was supposedly drawn from the site manager's personal experience, I presume he was meant to give the speech. The message in the introductory talk was consistent with the message that pervaded the whole meeting, his behavior at site safety meetings, and interviews I conducted with him.

7 Cf. the discussion of attribution error in chapter 10
At lunch, the site manager (who arrived after the morning break) told stories which illustrated the inconsistencies that arise in a system based on formal logic. (Note the importance of the meeting is signified by the most powerful person on the site attending.) In particular, he talked about accident investigations which reached conclusions that were hard to reconcile practically. However, they were consistent with the conclusions reached by following the incident investigation procedure (i.e. knowledge by accretion). Supervisors at the table also contributed tales. Here are the four I recorded.

1. A worker reportedly fell off a pickup truck and hurt his ankle. In response, management banned riding in the back of pickup trucks on site. There were two problems with this. First, no alternative transportation was offered. Second, he hadn’t fallen from the truck, he jumped.

2. In the manufacturing process at another site, the product used to stick to the inside of some columns. The operators would dislodge it by hitting the sides of the columns with sledgehammers. When someone mashed his finger, management banned the use of sledgehammers. Unfortunately, to obey the edict, they would have to stop production. Therefore, they continued to use the sledgehammers, but made sure the boss wasn’t looking.

3. A worker was hurt reportedly because the clips on his hard hat, which were supposed to keep his acid goggles out of the way when the goggles weren’t in use, pulled the goggles away from his face. Therefore, everyone was instructed to take the clips off their hard hats. One mechanic, who worked with the injured worker, was almost sacked for refusing to comply. He complied, despite the fact that he -- and everyone else -- knew that the victim hadn’t been wearing goggles in the first place.

4. The site manager’s favorite story involved an employee who burst an eardrum when hit from behind by a serve from his doubles partner. The manager chaired the investigation, but they weren’t sure what to do. The obvious recommendation was to ban people from playing tennis (which they elected to not do).  

At Widesite, the safety training went for three days instead of one because of the extra material. Also, the group was much smaller, 15 people rather than 30. This meeting also started with an introductory speech by a senior manager. Because he was late, the safety manager started off for him. The site manager gave an after-dinner lecture (note that this site manager appeared to think that the importance of the meeting was signified as much be what he had to say as by his attendance).

The message in the introductory speech was dramatically different from that at Highsite. The safety manager started by saying that there were two reasons for having the training. First, there was a legal obligation to ensure that people were competent to be supervisors under the local occupational health and safety act. Second, management wanted to increase the level of compliance and the effectiveness of safety management in the plants through enhanced understanding of the requirements.

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Transitech had extensive programs to ensure people’s off-the-job safety. All accidents away from work which resulted in people not coming to work had to be investigated formally, just like an on-the-job accident.
The key thing to understand is that we are now working to principles, and not to rules. Rules are easy and black and white. Principles are harder. They require interpretation and creating rules as you go. As conditions change, the rules should change, but the principles should remain the same."

When the senior manager arrived he established a framework for the following three days' instruction. His core message was that the facilitator's role is not to know the law, but to create a context in which the controllers will know the law.

In his after-dinner speech, the site manager addressed the question:

"How can it be, with all the time and effort expended by the company on safety, and all the additional time and attention applied by all of us on safety, that we still continue to have unwanted incidents and injuries?"

His central thesis was that controllers and mechanical tradespeople, when they do their work, are not approaching it with the appropriate mindset and commitment. He argued that the role of managers was to inculcate in the controllers a deep understanding of what it means to work safely. Then, they will be able to discern what it takes to be safe.

This principle-driven approach also found its way into other parts of the senior management rhetoric at Widestite. For example, when I interviewed the site manager or the assistant site manager about the workplace changes they were trying to engineer, they would constantly emphasize that the determinant of whether they would pursue a particular change was whether it would contribute to the success of the business.

Sense-making by supervision

But did these differences in management rhetoric find their ways into the organizations, or were they irrelevant to the way things were done in the end? And if there were differences, what was their extent? In this section, we examine sense-making by supervisors, while in the next we examine that by the production employees.

One day Highplant management wanted to conduct a biennial inspection of the bottom of some large pressure vessels (tall steel cylindrical tanks) which sat above the ground on skirts. The inspection required a technician to crawl under the vessel through a hole in the skirt with some ultrasonic equipment and measure the wall thickness.

The question arose as to whether the inspection required a confined space entry permit or whether it could be exempted as a "non-permitted" space under the site's revised confined space entry procedure, that was about to come into effect. Three supervisors, a safety officer, and a manager stood in the rain in the middle of a shutdown (when people typically work very long hours) and debated this for over two hours. In the end they concluded that the job would be performed in exactly the same way, irrespective of the permit, except that the permit would require a rescue plan. Such a plan would take approximately three minutes to write.

I asked the supervisor who had called the meeting why he had persisted so long in asking for a definitive ruling from the safety officer. He explained that he felt a permit was not required, but that he was not prepared to make the decision himself. Therefore, he wanted the decision to come from the safety office in collaboration with his boss. That is, he wanted a rule to follow to protect himself politically, and then he was able to proceed happily.
I can say with confidence that this sort of reasoning never would have crossed the mind of a Wideplant facilitator, and that such a rule would be unlikely to accord any political protection there. The supervisor would be expected to sort it out “intelligently”, and would be judged on that basis.

Sense-making by the production employees

At the level of the production employees I was struck with an interesting question at both plants. On the one hand, Highsite management was pushing a system based on strong formal rationality accompanied by the need to pay attention to things that don’t look right. On the other hand, Widesite management was putting a strong emphasis on practical rationality and principle-based operations. I asked whether the operators and supervisors actually had different cognitive processes for understanding events.

I was at Wideplant at the time, so I asked people to give me examples of incidents, and tell me why they were incidents. There were two or three dominant types of responses. Some people talked in terms of causes. “If this happens or that happens, then it is an incident, irrespective of whether something bad occurs.” The important thing was the potential for bad things to occur. A second group talked about effects. “If someone gets hurt, then that is an incident. But if no one gets hurt, then it isn’t.” A third group emerged clearly at Highplant, when I was attempting a quantitative test, though this group was probably present at Wideplant too. They talked in terms of the plant procedure for incidents. “According to the procedure, that isn’t an incident.”

I decided to see whether I could differentiate these perspectives quantitatively using a variant of a “Q-sort” approach. The general idea was that if people had different understandings of the world, then there should be some examples which one group would categorize one way, and another group would categorize another. So, as a first step, I would be able to show that the cognition at the two sites was different. As a second step, I hoped to test a set of hypotheses about cognitive changes which were meant to occur with the organizational change process. For example, Wideplant management hypothesized that people who had experienced day rotations to “know the business” better were therefore likely to have broader sets of definitions. Therefore, I expected a ‘causation’ orientation (practical rationality).

The initial task was to generate a broad set of incident-like occurrences. I did this by going around the control room at Wideplant and asking people for examples of six types of events. These varied from events that were definitely incidents through events that were probably incidents to events that were like incidents but were not incidents.

I typed up the examples, eliminated duplicates, and created structured variants of some examples. For instance, I generated about ten cases of tanks overflowing, varying along a number of dimensions. Tanks had either water, brine, or process chemicals in them. They alarmed full, interlocked out, or overflowed. If they overflowed, the material went to the ground, the waste treatment plant, or the river. I then asked people to perform a number of tasks. First, I asked them to simply sort the cards into piles and give the piles names. Then I asked them to sort the cards into events that Transitech would have called incidents ten years

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9 During the field work, I was identifying the different ways of approaching events. I had not yet mapped the behavior onto the literature.
ago versus those it would not. This was intended to get them to differentiate their own
training from corporate dogma. Then, I asked them to sort them into events they would have
called incidents ten years ago, versus those they would not. Then, I asked them to sort the cards
into events that management calls incidents now, and finally, events they call incidents now. I
generated a few more examples at Highplant, mixed them into the stack of cards, and continued
the exercise there.

I soon abandoned the exercise. I hit a practical problem and a number
of methodological ones. The practical problem was that people took at tremendous amount of
time to complete the exercise and I could get much more useful data, with much less resistance
from them, by just observing peoples' work. There were four major methodological problems.
First, when people gave me examples, they tended to refer to events that had occurred in the
plant. These events meant dramatically different things to people at the two plants or even
different production areas, so they tended to label them differently. Second, if people were not
familiar with a particular event, because they were in a different process area or at the other
plant site, they would ask me for a tremendous amount of contextual information which they
saw as vital to making a determination. Perhaps they were trying to map the prompt to a
procedure? I'm not sure. But, it was clear that if I provided all the information they wanted, it
would have taken hours for them to complete the exercise. Also, providing that information
credibly and consistently would be very difficult without much more planning. Third, over the
ten years, the external environment had changed, especially with respect to environmental
regulations. This would conflate any change in their thinking. Finally, people were very
sensitive to the wording of the cards. For instance, Highplant operators were very perturbed
when I used the term "back shift", the label for nights and weekends at Wideplant. While
this could easily be solved by creating slightly different cards for the two plants, it struck me
that words like "incident" probably also had highly localized meanings. Any result could be
either a difference in the local meaning given by management, or different cognition.

Although the exercise was a failure in a "statistical" sense, I decided to pursue another
tack. I obtained copies of incident investigation reports from a third "compound" plant in
Transitech. Some time in the future, I will use these reports to write a questionnaire which I
will administer.

In the mean time, the exercise suggested two interesting things. First, all people
seemed to be quite capable of being both practically and formally rational at the same time.
Just like the supervisor inspecting the bottoms of the tanks, people (with one or two exceptions)
had no trouble understanding that they could understand a given event two ways. They could
call it an incident on the basis of their personal theory of the world. At the same time, the
company may, or may not, have called it an incident. Second, there appeared to be minor
differences between the plants, with people at Highsite being more formally oriented and
people at Widesite being more practically oriented.

**Problem-solving**

While sense-making is about determining how a particular outcome came about
problem-solving is the process by which people link two image schemas.
In this section I will give two examples. The first is that of engineering design, while the second involves the design for the implementation of the lockout and tagout procedure. In both cases, I want to show formal rationality at Highplant in two ways and contrast it with behavior at Wideplant. In the first case, I will assert that Transitech management was instructing engineers to create designs on the basis of some faulty premises. That is, the "desired state" was wrong. Despite the fact that these premises were faulty, the engineers did not question them -- an example of formal rationality. I will then show that the effective use of employee participation in the design process, as was the case at Wideplant, appears to overcome the problems with the faulty premises. However, employee participation at Highplant -- much more of a formally rational process where the employees appear to be brought in a more token way -- did not overcome the problems. In the second example, I will show the way a set of cultural norms around safety management led to a lockout and tagout procedure which was too complicated to implement safely. I will then describe the difficulties one Highplant employee had trying to be practically rational with a task he was given -- that of designing the implementation. In many ways it parallels the story of the Highplant engineer's attempts to get operator support for the design for the new process "C" (chapter 9).

Problem-solving by the engineers -- design

Before proceeding with this example, a brief methodological note is in order. I wrote it up originally and submitted it as part of the first draft of the dissertation for a "proprietary information" review. All of the Transitech reviewers said that the phenomenon I was describing could not possibly be occurring in Transitech. Following that, I conducted extensive correspondence with two highly respected engineers with whom I had a good relationship, one at Wideplant and one at Highplant. Thousands of words went back and forth as we worked through the issues. The story I am telling here is more accurate than not, even though there are some confounding factors (mainly because I focus on one design principle only instead of a whole set and the failures I describe involve inappropriate use of these other principles as well). My proprietary information agreement requires me to be vague on the details.

Engineering design is an organic process in which common sense, experience, and logic are applied to a technical problem. It is, in essence, an exercise in practical rationality. Underlying this, however, is the technical specification of the task -- the "desired outcome"
which the engineers strive for (in terms of the "problem-solving" schema above). With the rise of the Japanese automobile industry, a number of novel design principles emerged. One of these is the idea that production facilities should have minimum buffers. Researchers observed that by minimizing the size of the buffers in an assembly plant, cash flow improved and defects in products or production appeared rapidly in the system. Therefore, while this design was very inefficient in the short term, it was extremely efficient in the long run because problems had to be fixed rather than being worked around (Krafcik 1989). A second idea was that of not changing a design once it was finalized. The principle here is that design changes late in the design cycle of a car required very expensive redesign of both the car and the production equipment. A third common idea was that of minimum essential design. The production facilities shouldn’t have unnecessary bells and whistles which add to the cost and complicate the operation unnecessarily. A fourth idea, which is not part of the "Japanese package", but was practiced in Transitech, was to minimize the capital cost. This often entailed using cheaper components than were desirable.

While these principles make a lot of sense for automobile production, in the main, they have strict limits for chemical production. We will consider the case of minimum buffers, though I could make an equivalent argument for the other principles.

Minimum buffers minimize capital costs and force errors to be fixed. The problem with a capital cost minimization argument for chemical plants is that buffers consist mainly of storage vessels, and cylindrical storage vessels exhibit tremendous scale economies. Their volume increases with the radius squared of the vessel, but cost varies with the radius. You don’t save very much unless you eliminate them completely.

As for the errors being fixed, the problem here is that the time constant for a chemical plant is huge compared to that for a car production line. A production line can be started up in about 45 seconds. Even with minimum inventory, there is always enough material in the process to get the plant to steady-state operations in about a minute. Startup is not an issue that even needs to be considered in the design. Design is for the steady state. Furthermore, if something goes wrong and the process must be shut down, it stays frozen in place until it can be started up again. Chemical plants are completely different in these two critical respects.

This difference creates three problems. First, as we saw in chapter 4, plants take days to start up and line out. Therefore, if there is less than several days of inventory available, nominally decoupled facilities or sections of processes have to be taken up and down together. There is insufficient inventory to start up or shut down separately. Needless to say, bringing up and down three facilities with very different operating characteristics simultaneously is much more difficult than doing so separately. Second, if plants have to go up and down simultaneously, they have to be maintained simultaneously, or downtime is horrifically expensive. This means that the short-term mechanical labor force has to be much larger for a minimum inventory plant. Third, operations will be much more unstable in tightly coupled (low inventory) plants. Because of their tight coupling of components, operating problems in a chemical plant tend to propagate widely. If interlocks fire like dominos, then small

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10 The claim is not that they are invalid, just that they have limits. As a counter example, one Highplant plant leader complained to me that there was so much storage capacity between processes B and C (an artifact of the history of the plant and its commissioning, not the design process per se) that the two groups didn’t talk to each other nearly as much as he would like. See also the way the two groups have an obstructed view of each other in figure 6.1.
inventories allow the dominos to propagate further faster and the problems to magnify. If this third problem is paired with inferior components, plants can quickly become inoperable.

In the five years prior to and during this study, some senior Transitech managers decided that their engineers should apply these Japanese automobile principles to the design of some new plants (cf. DiMaggio and Powell 1983). Engineers went off and dutifully applied them, with predictably disastrous consequences. A number of facilities were built around the world, at a cost of hundreds of millions of dollars each.\textsuperscript{11} They were essentially inoperable. Operators were simply unable to start up plants with three hours (or less) inventory available instead of the usual three days (or more). They fought for months to start up one plant, and eventually got it running after spending several million dollars to add in extra process inventory. However, after a few hours of steady operation, a pump blew up (it was bought cheaply) and the whole process crashed. The corporation decided to abandon the investment entirely rather than spend another 50 million dollars to fix the problems.

In other cases, they had to go back and add in inventory once they found the places where it was critically short. Not only was this expensive because a physical location for it hadn’t been designed into the facility (because of the minimum essential design principle), but the corporation was paying interest on the capital, and customers were waiting for product. Parts of the new Highplant process were designed using these principles. This led, in part, to a series of capital expenditures and production shortfalls of about the same order of magnitude (but significantly less) as the capital cost of the facility. That is one of the main reasons why I have chosen not to compare plant performance quantitatively. There is a good chance that, despite its superior control and manufacturing technology, Highplant is intrinsically harder to operate.

While this had been a problem at Highplant, it is noteworthy that Wideplant had had tremendous success in the previous few years bringing facilities (albeit on a smaller scale) on line. They had had more than their share of nasty and expensive technical problems (design errors from poor assumptions about the behavior of materials). Also, they were firm proponents of the “minimum buffers”, “minimum essential design”, and “no bells and whistles” principles. However, they had had no problems of inoperability. That is, once the engineers got the materials to behave the way they were supposed to, the operators had no trouble running the plants. While it is tempting to invoke a “skill” argument to explain the difference, it seems that the main difference is the process by which the plants were designed. The Wideplant engineers seemed to spend a huge amount of time on operability issues with the controllers, and the controllers were really integral to the design process. As a result, they built operable plants. In contrast, at Highplant, operators complained to me that, with many (but not all) of the engineers, they had to force the operability issues, and that the consultation about how the new facilities would work had been extremely narrow. These are consistent with the idea of operator participation occurring out of a formal requirement imposed on the engineers, rather than the engineers believing it is a good thing. To this litany of woe, we have to add the observation that the detail design for the facilities was performed by an external consultant, with the Transitech engineers in a liaison role, not by Transitech engineers directly. We would expect that to reduce the consultation with operators further still since there would be no personal relationship between the external design engineers and the operators.

\textsuperscript{11} The empirical basis for the argument in this section is discussions with (frustrated) engineers involved, directly or closely, with four large capital projects that came unstuck or were predicted to have serious problems when they tried to come on-line. Three of these were associated with the “compound” business. Only two are discussed here.
Lock boxes

The role of formal rationality in process safety management provides the second "problem solving" case. Again, the example has three parts, the first of which describes the formal rationality which led to the situation. The second describes the role of organizational process in creating practically rational outcomes. Finally, we contrast the situation with Wideplant where there is an outcome which has clearly evolved as a result of a practically rational process.

In the early 1990's, OSHA promulgated a new process safety management standard. Rather than asking the plants to comply with the new OSHA code, Transitech wrote a new procedure, just a little bit more stringent than the OSHA code. For various reasons (which can't be elaborated) it can be shown that Transitech management, if asked to approach the problem practically, would assert that the OSHA code was sufficient. However, Transitech had a norm of having safety codes stricter than the law. Highplant management then created a site Process Safety Management Committee which wrote some site procedures just a little bit stricter than the corporate standards. Each plant on the site then developed its own implementation of the site code. Not surprisingly, it was just a little bit stricter than the site code.

The result was that many of the plant-level provisions were so strict that they were both very expensive and very difficult to implement. "Lockout and tagout" provides one example. OSHA required that firms put tags on lines that are being maintained, to indicate they have been cleared. However, locking out was preferable. The Transitech procedure required that the line be locked and tagged. That is, the operators had to put a chain on the valves and lock the valve in the correct position for clearing. The Highsite procedure required that a different key be used for every lock in the tagging job, rather than having all the locks operate on the same key. This meant that, for a large job, the operators had to work with about 300 different keys. In many areas on Highsite, though not Highplant, plant management insisted that the keys be kept in lock boxes that were outside the process area where the job was performed, meaning that the mechanics had to somehow transmit the location of the keys for the various jobs to each other and complicate the job further.

The Highplant decision to put the lock boxes in the building, near the job, was an innovation developed by the operator who designed the implementation and is an example of avoiding a formal/accretive outcome. The various topics discussed -- stupidity, need for compliance, his surprise at the spontaneous response, and the lack of (expected) resentment -- are the elements of the story he thought were important. All are consistent with the thesis of this chapter.

An operator and his supervisor had been on the site committee which had written the procedure. The operator was put in charge of implementation, though the supervisor gave him clear instructions about exactly how it should be implemented (formal beginnings). After trying to do it for a while, the operator decided that such an implementation would be virtually impossible to achieve. The resistance from the other operators would be terrible. So, he went to the supervisor and said that they could fire him, transfer him, or send him back on shift, but he wasn't going to do the job. It would take two people to do the job the way the supervisor wanted. The supervisor called in the plant leader, but the operator still refused. The plant leader then met for an hour with the plant specialist and the supervisor. After the meeting, the operator was given permission to implement the procedure any way he wanted.

The operator then undertook a three-stage process. In the first stage he talked to the crews and asked them what sort of a system they wanted. They all said the whole procedure was really stupid. He agreed, but said they would all have to comply with it anyhow, and asked how they wanted to do so. The operator used their suggestions to sketch out some
alternative implementation plans and circulate them for comments and feedback.

In the second stage people realized that he had been serious when he had said he wanted to listen to them. Their ideas were coming back on the sketches. They started to respond in a spontaneous way, sending messages and dropping by the office to ask him if he had considered this, or that. All he had to do then was follow up on the better ideas. He found that this saved him a huge amount of time. He didn't have to think through the problem at all -- all he had to do was to put together the various ideas. All the problems were flagged for him.

In the third phase, management implemented the technology and did the training. The training went very smoothly for two reasons. First, the operators were already familiar with the basic ideas before the training occurred. Second, they didn't resent the operator in the training role; they accepted that he was only the messenger and not the originator of the new requirements.

The operator told me of three pieces of feedback which indicated to him that he had done a good job. First, the implementation costs in his area were about $100,000 less than other plants' $200,000. Second, compliance with the procedure was at twice the level of the other plants. Third, people from other plants on the site and other Transitech sites started coming over to look at their system, and in fact, started to adopt elements of it. Apparently, the safety office told the visitors not to bother looking at other plants on the site.

As we saw in chapter 10, the Wideplant implementation of the same procedure was quite a contrast. The focal site for each plant was a room. On the floor of the room was a series of buckets. Painted on the side of each bucket was a number. In the bucket was a set of chains, and one key. On the rim of the bucket were a bunch of locks. The key operates all the locks. On the blackboard was a table with the names of the various systems in the building, the bucket number corresponding to that system, and the number of locks and chains which should be in the bucket. Also in the room were copies of the tagging lists for the various jobs that were done on the various systems. These indicated exactly where, for the various jobs, the controllers had decided were the best places to put the locks. If someone was going to tag a job, they took the bucket for the relevant system, and the relevant tagging list, and performed the job. If the sub-system they were tagging didn't require all the locks, they still used the appropriate bucket. At the end of the job, all the operators and mechanics who worked on the job reviewed the tagging list, made sure it was accurate, and suggested improvements. It was clear, just from walking into the room, that the controllers and mechanics had put a huge amount of effort into designing a system that was easy to implement and easy to check. For example, by counting the number of locks on the rim of the bucket, the controller could either a) make sure they had hung all the necessary locks and tags, or b) check they had removed all the necessary locks and tags.

**Human resources programs**

The differences in rationality could also be seen in differences in programs to implement strategic objectives. We saw this in the recruiting programs. Differences in approaches to affirmative action also illustrate this. At Highsite, it was quota-based. This created a lot of resentment, but it was effective. Operators and mechanics consistently felt they were being supervised by people selected by quota, not merit. This reinforced race and sex-based stereotyping on the site. Similarly, many of the young male engineers felt they were
unpromotable because of the women in the organization.\textsuperscript{12} Widesite, on the other hand, tried much harder to work on the basis of merit. This is not to say that Widesite management wasn't sexist; many of the women felt it was. Rather, Widesite management dealt with the sexism by trying to create a meritocracy and by making training available, rather than by pushing people who weren't necessarily qualified up the organization on the basis of an algorithm.

Finally, we can see this tendency in some safety tests that were designed at Highsite. One test was for the "process safety management" program. Three supervisors had sat Jown for weeks developing a test as part of the site's internal certification system under the OSHA regulation. Unfortunately, the supervisors hadn't thought to decide what parts of the training were important, and what parts were not. Instead, they produced several hundred questions to be administered by computer, on the finest details of the training, such as the number of people killed at Bhopal (a number mentioned in passing in one of the videos). As such it was very similar to the contractor indoctrination (described in chapter 5). There I suggested that the videos went into the minute details of the management of the site because the company wanted to protect itself legally. An alternative hypothesis is that the people who designed the videos didn't know to think at all about what they were trying to achieve with the videos, or the best way to achieve it. Instead they simply tried to cover the terrain. Certainly, my discussions with the people who administered these videos to the contractors (the videos were about a decade old) would suggest this sort of lack of understanding.

**Problems with the two ways of knowing**

**Problems with formal/accretive rationality**

There are three major problems with formal/accretive systems. The first is that excess emphasis on compliance, and optimization in terms of formally rational systems, can lead to practical irrationality, as well as excess cost. The second is that, in such a system, people with power have a license to be capricious. The third is that if it fails, people don't know what to do.

**Formal rationality yielding practical irrationality**

I will provide nine examples of expensive or irrational compliance at Highplant, and two from Wideplant. First, I interviewed the head of the site "interlock" committee. He was responsible for the interlock testing procedure and ensuring that the tests occurred. He noted that each process had about 500 interlocks and that many of these had been installed to protect expensive equipment. They had no safety usage. Furthermore, the interlocks for safety were protecting against hazards of dramatically different sizes. However, all the interlocks on the site were being tested at the same frequency. Therefore, he proposed that the site not require testing of the equipment-protection interlocks at all (this should be up to the businesses), and

\textsuperscript{12} I was told by a manager that promotions and performance ratings for the professionals at Highsite are strictly merit based. None of the junior professionals appeared to believe this.
that the hazard associated with the safety and environmental interlocks be assessed, with the testing frequency varied accordingly. When he first proposed this, he had tremendous resistance from the site process safety management committee. The committee chair liked the idea however, and so they decided to proceed.

Second, one of the indicators which the plants use for their operations is "planning and scheduling compliance", the proportion of jobs which are scheduled two or more days in advance. This indicates that maintenance is planned, and not done to fight brush fires. During an audit in anticipation of "corporate maintenance certification", the corporate maintenance representative instructed them to stop deferring emergency jobs for two days so they wouldn’t show up as “planning and scheduling violations”. Instead, they should do the work immediately and see what their real problems were like, even if it meant getting a higher score.13

Third, in a very similar way, I watched the "respirator fit testing" of some mechanics. Once a year, they ensured that the mechanics would get a good seal on a respirator if they needed to use one. To my extreme surprise, the mechanics tried to maximize their fit score by sitting absolutely still while the test was done. It seemed to me that it would make much more sense to move around as much as possible since you would be very active in an emergency that required a respirator.

Fourth, at a morning meeting at Highplant, the supervisor announced that there were no safety or environmental incidents to report. In the next sentence, he announced that there was a leak in one of their supply pipelines for a flammable input. Clearly, this didn’t meet someone’s criteria for a safety or environmental incident. (This didn’t only occur at Highplant. Regularly, at the Wideplant morning meeting the panel controller would announce that there were no environmental incidents, and then announce that they had overflowed a tank somewhere in the process.)

Fifth, and very similar, was a problem they had with some bad meters in area A at Highplant. As part of the DCS installation, they had installed 300 new digital meters. Unfortunately, because of a hardware fault, many of them were intermittently defective. Between the installation of the meters and the first “incident” involving a meter failure, about 30 of the meters failed. That is not to say that people weren’t doing things to try to work out which meters were defective and to get them fixed, but rather that no one suggested to the operators that they might want to change the way they run the plant until they had overflowed (and essentially destroyed) a tank.

Sixth, one of the Highplant supervisors had to develop a scheme to determine which of the operators needed ongoing training, and which jobs they would need training on. This was mainly important for the operators who worked days, since they only got to practice on the plant when they worked overtime. As such, there was a risk that their skills would slip. At the meeting to discuss his proposed training regime, no one in the entire organization chose to notice that he had decided that two of the operators did not need to get ongoing training, because they did administrative work while working a shift schedule. It would seem to me

13 It is important to realize that the whole idea behind the maintenance certification program was to have people do the maintenance when the need first arose because deferred maintenance tends to propagate problems through the plant. If someone chooses to defer maintenance to improve their planning and scheduling compliance, they have completely missed the point of the whole program.
that the important thing which determines whether someone maintains their skills is the job
they do, not the hours they work.

The seventh example involves an engineer and his plant production leader in another
plant on Highsite. The engineer trained as a mechanical engineer, and the supervisor was a
chemical engineer. The engineer was asked to carry out periodic process hazards analysis on a
section of the plant which had hardly any capital work done on it in the previous five
years (the frequency of the reviews). Process hazards analysis is a suite of techniques
developed by chemical engineers to determine whether or not there are unanticipated risks
associated with a plant system. The important thing to realize is that the techniques assume
that the problems associated with the plant are to do with what is in the pipes. That is, you
worry about "what would happen if this gas escaped, and are we protected against it?" The
engineer reasoned that they could deal with the changes to the plant relatively quickly, and
any other time would be spent reproducing the findings of the prior analysis. He went to his
supervisor and proposed that they devote a significant proportion of the time to corrosion
inspections instead (i.e. the integrity of the pipes themselves -- a mechanical engineering
problem) since that hadn't been looked at in detail. His supervisor instructed him to do the
analysis in accordance with the corporate procedure.14

Eighth, an engineer, also in another plant at the site, was responsible for
environmental compliance for a large number of processes. Under the decentralized safety
management system, the site manager was also "holding people accountable" for environmental
performance. The engineer complained to me that the site manager neglected to consider the
risks to which each person was exposed, or the control that person had over the risk.
Therefore, whenever there was a spill in that portion of the site, the engineer would be hauled
into the site manager's office and be told he was accountable. Because his responsibilities were
extensive, their meetings were frequent. He feared that he was becoming unpromotable because
of this.

Finally, while I was at Wideplant I did a telephone interview with one of the chairs
of the Highsite safety awareness committee. In the course of the conversation, I noted that
Wideplant had a safety meeting that day in which they brought a sports car onto the site with
switchable anti-lock brakes. People were driving the car around an area on the site, with a
speed limit of 20 mph, and trying the difference between anti-lock and normal brakes. In
addition, they received advanced driving tips. The interviewee pronounced, in horror, that
they would never do something so dangerous as part of a Highsite activity.

There were also two examples of this type of behavior at Wideplant, though not
nearly as blatant. First, during one of the materials crises in area "A", they had to keep rail
cars on a siding in town. Simultaneously, the business manager was putting pressure on the
overtime rates in the various areas, and the controllers were very upset about their loss of
overtime income. When the production coordinator chose to pay demurrage, rather than put on
overtime (at a lower total cost), the controllers were quick to tell me how the company was out
to get them. In fact, the production coordinator was probably just responding to pressure from
the boss, or wasn't thinking clearly.

14 I also met with the supervisor, but didn't get a chance to ask him about this directly. From
meeting him, and knowing the engineer reasonably well, I feel it is unlikely that he feared
that the engineer was simply trying to avoid work. Rather, it is much more likely that
the supervisor saw compliance with the procedure as being more important than material
outcomes. There were no program to look at corrosion in the plant at the time.
The second is a "half" example in that management tried to assert its authority, but the plant resisted it by clever isomorphic behavior. One of the most successful aspects of the Widesite prototype site was the use of "customer champions". These controllers became very excited about their work because they enjoyed going to customers' sites to help with the use of the Transitech product. Customers, in return, became very excited about Transitech. The business manager put tremendous pressure on area B-C to implement the same system. The area facilitators decided to "show" the business manager that they were doing essentially the same thing with their customers as the other area, but in a different way. Rather than comply completely with his request, they wanted to appear to comply but be left alone. They didn't try to explain to the business manager that the nature of both the use of their product and the customer base was such that the customers had much less need for a technician liaison role, and much more need for highly specialized engineering assistance.

**Formal rationality and caprice**

I will provide a third example of unchallenged caprice at Highplant, in addition to the two we have already seen: the example of the plant leader insisting that they 'manage risk' and run the dryer even though all the supervisors recommended against it (see chapter 9), and the example of the supervisor who insisted that the operators not defrost some equipment when common sense and standard practice both suggested they should. There are several others in my field-notes.

Every so often they had to 'shop' valves in shutdowns. This meant that they tagged out the systems, put blanks in the lines, unbolted the valves, pulled them out with a crane, sent them to the central workshops, had all the moving parts cleaned and sharpened, and then reversed the process. It was very expensive, since there were many valves in a building. However, it was also very important, since the valves provided control over the process and protection for the mechanics who worked downstream from them. Leaking valves are very dangerous. They are also very expensive to fix since an emergency shutdown is often mandated. Some operators claimed that, in the past, the Highplant valves would be shopped every shutdown. However, six years prior, they went to a frequency schedule, where each valve had a different frequency. The problem was that every plant leader in the prior six years had deferred shopping the valves to 'manage the business risk'. The result was that many of them had not been shopped in six years. The operators thought the plant leaders simply hoped it would not all come crashing down on their watch. If it did, they would deny responsibility because they could claim not to know the work hadn't been done as scheduled (cf. Jackall's (1988) description of plant managers milking their plants).

**Formal rationality and organizational breakdown**

The final problem with formal/accretive systems, is that people don't know what to do if there is no one to tell them and no procedure to guide them. This means that the whole system has to be very tightly controlled to maintain its effectiveness. It was with this in mind that one of the site safety managers explained to me that it was absolutely vital to maintain the safety standards on the site. If you don't, he complained, people don't take anything seriously. Audits don't get done properly, procedures don't get followed, and so on and so forth. Put differently, people don't have a basis for determining what is truly important, and what is not. Therefore, there is a chance that they will let the wrong things slip. Fortunately, I have no examples of this actually happening.
Problems with practical rationality

While emphasis on compliance and formal rationality can lead to a wastage of resources and caprice, emphasis on practical rationality can lead to excessive risk. Standards can slip easily. I will give many examples from Widesite and one from Highsite. The first Widesite example involves the findings of the Wideplant joint (labor and management) health and safety committee. The union members of the committee persuaded management to allow them to conduct safety audits significantly in excess of the legal requirements, and so two teams would each audit 1/24 of the production areas on the site each month. In these audits they would find a large number of items which were out of legal compliance, and report them to the management of the various plants.\footnote{On reading a draft version of this manuscript, Wideplant managers denied that there were any legal compliance problems in the plants, and that the union was simply claiming that things were out of compliance. They explained that management would choose to respond to the unions claims, even though there were no legal problems, if it thought there were valid safety issues involved. Without a legal opinion or an inspection by a government safety officer, it is not possible to differentiate the two claims.} To my surprise, many of the plant production coordinators were very hostile to these audits and their findings. When I interviewed one manager about a protracted battle with the union over some equipment in his facility, he explained that running a plant isn’t black and white like the union thinks, and that there are trade-offs that have to be made, and sometimes you choose to not do very expensive things, even if they are required by the union’s reading of the law, if you decide the plant is safe enough without the changes. In other words, he used a practically rational argument. However, he was either contravening or coming pretty close to contravening the corporate policy that the plants will be in full legal compliance at all times.\footnote{There were two other contributors to the frustrating relationship between management and the union over joint health and safety. First, the union was clearly using the committee to get under management’s skin, and people in management resented this. I sat in on a joint health and safety committee meeting and there was a huge amount of conflict over issues that neither side really cared about. In addition, the union refused to acknowledge some of management’s concerns. Stories of these conflictual meetings had circulated around the site for a couple of years. Second, for several years, the union had such a formally rational outlook on the plant’s operations that they didn’t understand the workplace changes management was trying to make. Management, by the same token, wasn’t prepared to try to understand the union’s position. Therefore, conflicts would continually erupt over things that the union thought was important but which management thought was irrelevant (such as whether an accident investigation was carried out in strict accordance with the procedure).}

Second, during a very cold snap sometime around Christmas, the pipes which supply the safety showers for one of the Widesite buildings froze. The process materials in this building were extremely corrosive. People thought the pipe froze sometime between December 23 and January 1. The controllers thought it was around the 23rd, when they had some power outages. The facilitators thought it was around January 1 because that was when it was first noticed, and they would have expected big icicles on the pipes if it had broken before then. The failure was caused by someone resetting the alarm on the safety shower recirculation pump but not restarting the pump. Both corporate regulations and the law insist that showers be available whenever risky work is undertaken. However, make-shift showers were not in place until about January 21, and hot showers were not available until late February. Hot showers
could have been available by about January 8 if they had decided to implement their eventual solution immediately.

Four streams of activities were carried out over the three weeks between January 1st and January 21st. First, the controllers operated the plant. This included taking samples (which required direct exposure to the process). Second, the mechanics repaired the plant as they normally would. Third, the controllers lobbied to have the shower system fixed. Fourth, the mechanics fixed the showers. Only one of these activities, the mechanics doing ongoing maintenance in the plant, was carried out in a practically rational way. In this case, the mechanical facilitator required that an extra mechanic stand by with a running hose to spray anyone who was splashed with process material. The three other activities were carried out with surprisingly little consideration of the need to provide some sort of safety system. I will consider the three of them in order.

First, consider operations. The operators put a note in the shift report for January 1 (which is read at the morning meeting) saying the showers were broken. They didn't write it into the shift log (which all the operators can read if they want to). No notice of the problem found its way into the shift guidelines, the document which each shift is required to read, until January 17, telling the controllers that they should have someone stand by with a hose while samples were taken. In the mean time, they did hang signs on the building doors warning people that there were no safety showers. However, many of the controllers I interviewed said that they didn't notice them, and even if they did, they didn't see how it applied to them. In other words, despite management's rhetoric about controllers understanding the total business, the controllers did not think broadly enough to protect themselves when doing standard production work. By the same token, the operations facilitator didn't take it upon himself to tell the controllers to protect themselves (as his mechanical counterpart did).

Second, consider the controllers' actions to get the showers fixed. A number of them were aware of the problem, but they did nothing. Legally, they could have refused to work, but they didn't do that because the business was under threat from the corporate level. Alternatively, the controllers could have brought the matter up with the production coordinator or the business manager, but they didn't want to be thought of as trouble makers. Alternatively, they could have gone through the union steward, but he didn't want to make trouble because he had a bad reputation from a fight the previous year where he prevailed on management to install a safety shower which management didn't want to pay for. Eventually, on January 18, one of the controllers had a fight with the maintenance facilitator about the lack of action. He was so angry about the interchange that he contacted the business manager, who called the maintenance and production facilitators on January 19.

Finally, consider the repairs themselves. There were two problems. First, it took a few days to determine where the blockage was, steam the pipes to melt the ice, and discover that the pipe had, in fact, split. (The mechanics discovered in the process that the technique they had been using to test the showers for blockages was actually flawed.) Second, they discovered that they needed special galvanized parts, and that none were available. The parts would have to be imported. This would take three months. So, they put up signs, as they had done

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17 This was another case where the legal requirements were ambiguous. However, in the end, the controllers brought in the safety officer, who recommended that the plant buy the shower. Safety showers cost hundreds of thousands of dollars because they have to provide very tightly controlled water temperatures in a wide range of ambient temperatures.
last time the showers split, and waited. On January 14, someone in another building in that area was sprayed with process material. On the following Monday (January 17) the operations and maintenance facilitators decided that showers really were necessary. The next day, the two of them designed a setup for connecting hoses into some of the showers. They contacted the site safety manager that day, and met with him on the 19th or 20th to have their design approved. In the meantime the business manager called -- somewhat irate -- and the facilitators told him everything was under control. The hoses came into service on January 21. Some weeks later, someone had the inspiration to install non-galvanized fittings until the galvanized ones arrived. They arrived in a few days, and were installed promptly. There was much rejoicing.

As we can see, with the exception of the maintenance facilitator who instructed his mechanics to have a hose standing by, all the other actors -- the controllers, the operations facilitator, and the production coordinator -- failed to think practically enough to ensure the safety systems maintained their integrity. There wasn't a strong formal system backing them up to make sure that nothing too bad happened.

Five more brief examples illustrate the failures that can occur if formal procedures are not in place and people don't exhibit sufficient practical rationality. First, a manager decided that the workers in the laboratory didn't need annual hazardous materials management training. The representatives from the union weren't able to persuade him that it was the law. Eventually, the chairs of the joint health and safety committee had to send him a strongly worded letter. Second, we saw in chapter 6 that the controllers had failed to clean up the frozen ice rinks in process 'A' without being asked. Third, they didn't do anything about the 60-foot icicle until the production coordinator got upset, and we saw that one controller still refused to do the work. Fourth, for a while, there was a problem with shift change-over occurring in the parking lot. People were supposed to wait in the control room building until their relief arrived and then brief them on the state of the process. Management didn't feel that people were taking appropriate initiative by doing this through their car windows. Finally, each area at Wideplant was meant to have a weekly safety audit. However, as we saw, the vast majority of these were cancelled because the work was so pressing that the controllers who led them never seemed to get around to finding time to do them. At Highplant, in contrast, they always happened.

The Highsite example comes from the mid-1980's when organizational effectiveness was at its zenith. At that time, operators would regularly revise the procedures as part of their "empowerment". One engineer told me how he read procedures and discovered two things. First, they were no longer intelligible. Second, insofar as he could understand them, they would often violate the phase chemistry of the production process.

These five examples illustrate the down-side risk associated with an organizational system based on practical rationality. If people don't have the capacity, or organizational politics precludes them from exploiting the capacity, to effectively solve problems as they arise then there is nothing "backing them up" to make sure that a set of minimum standards are met. Instead, the entire integrity of the system rests on their ability to understand their situation, and act intelligently on that understanding. In very large, complex, and political socio-technical systems, that is a lot to ask.
Conclusion

In this chapter, I have demonstrated that there are three fundamentally different ways to know the world: practical, formal, and accretive rationality. Two of these, formal and accretive rationality, go together to create two modes of rationality. People's actions at both plants was a mixture of both. While the vast majority of behavior in both plants (routine operations) was both formally and practically rational, there were many cases in exception management where we could see the two diverging. In these cases, Highplant tended to be more formal in its approaches, while Wideplant tended to be more practical. Excessive formal rationality is very wasteful and permits caprice, while insufficient formal rationality can be dangerous and cognitively very taxing. In general, these differences contributed to higher performance at Wideplant, but at an important cost. It also increased the risk of something untoward happening because people hadn't thought through their situation carefully enough (or it was too complicated to understand). The excessive formal rationality at Highplant also had a risk associated with it. Here, the possibility of caprice meant that people with power, who thought they knew more than they did, could impose their will on the organization and expose others to excessive risk. As such, neither practical nor functional/accretive rationality alone provides a panacea in real organizations. Instead, managers need to find a way to use both simultaneously so that each covers for the other's defects while preventing its defects from getting in the way of the efficiency created by the other.
12. The role of flexibility

Wait a minute! Something doesn’t make sense. To an outsider, Wideplant looks like a dream: multi-skilled workers working together with seamless efficiency, high productivity and reliability, teams and teamwork, people learning the business, and therefore lots of happy workers, shareholders, and other stakeholders. To someone who knows a little more, it looks like a disaster waiting to happen. We had the shower fiasco where no one would take responsibility for a task which was in everybody’s interest (chapter 11); we have numerous cases of safety inspections not happening, safety training not being performed, audits being cancelled, and recommendations not being followed up on. We have a system of work organization predicated on people being able to generate rules on the basis of ‘principles for behavior’. However, this seems ambitious when many of them can’t even read the manual for a word processor, and one crew on the site didn’t even know how to start up its process when it shut down unexpectedly (chapter 6).

Something seems to be amiss. In this chapter, we consider the final element of the explanation of the differences between the sites. We ask how it is that the Wideplant organization can have such obvious problems, and still be high performing. There are two obvious hypotheses. The first is that the differences laid out in the previous four chapters are sufficient to explain the performance differences. This would be an essentially technological argument. The central claim would be that the technology has a certain level of complexity and tightness of coupling, and accordingly, needs a certain level of organizational proficiency to run smoothly. If that level of proficiency is met, the system becomes essentially self-correcting because the organization can outrun its mistakes. If, however, it is not, errors and exceptions tend to multiply and bring the plant down the whole time. At the time of the study, so the argument would go, Wideplant with its higher skill levels, greater attention to the core technical processes, people knowing the “total business” and fewer encumbering rules, was operating above the threshold, and Highplant was operating below. We would expect, occasionally, that the system would break down and something untoward would happen, as with the safety shower incident, but otherwise, the plant should be more reliable.

This is essentially the argument that Wideplant management would make. However, it doesn’t accord with the empirical reality. At the time of the study, morale was low and there was widespread disaffection with the change process. While people did have higher skills, it is hard to see how, with only about 20% of people enthusiastic about the change effort, performance would be so much higher.

It would seem that the Wideplant organization has some intangible quality which helps it to facilitate skill formation and robustness against these sorts of errors (or ‘fault tolerance’ to use the engineering term). This same quality also seems to enable it to get the most out of the 20% of people who were enthusiastic and hardworking during the study. I will call this quality ‘flexibility’. The chapter will be divided into two parts. In the first, I will define and operationalize flexibility. I will do this by drawing on data from the study and other pertinent examples from elsewhere. A key part of the definition will be that flexibility will be defined as a characteristic of aspects of the organization, not of the organization as a whole. In the second half of the chapter I will show the ways increased flexibility in some domains improved performance of Wideplant over Highplant, but that in other domains, Wideplant was less flexible than Highplant (and less flexible than it had been) and that this was a source of tension and productivity loss. In other places still, one plant was more flexible than the
other, and this was not a good thing at all.

Defining flexibility

A definition of flexibility must be consistent with our lay understanding, reasonably
generic, and differentiable from other relevant constructs. My lay understanding of flexibility
is that it is, in some sense, the range of "positions" the organization can occupy at low transition
cost. For example, we would say that an organization is flexible across a range of two products
if it can produce one product, and then the other, and then go back to producing the first with a
relatively low cost associated with the transition (in either direction). If the cost were
significant in either direction, or asymmetric, we would call it organizational change.
Furthermore, rate is important. For it to be flexible, the organization must be able to swap
products faster than the demands from the environment change. Finally, we are not interested
in any cost reductions coming from the experience (which we would call learning or innovation).

However, we don't want to limit the definition to simply the ability to make different
products. Therefore, I will define flexibility as the ability of the organization to accommodate
variations in environmental stimuli or variations in the strategies of actors, without actors
being perceived as acting politically. That is, flexibility is the amount of change in any
relevant domain that can occur without actors feeling conflict or resistance. Or alternatively, it
is the amount of scope that the actors have to maneuver in a particular situation. Flexibility,
therefore, is situation specific, except in so far as the organization is generically politicized
and therefore all action is inhibited. Flexibility depends on the particular domain in which
people are acting (but should be independent of their power). An organization could have very
flexible capital allocation but very inflexible human resources management policies, for
instance. Similarly, it is possible to imagine an organization which is very flexible, but has
only one product because that is all the market demands.

We see the importance of including politics in the definition if we consider a flexible
machine system. In addition to having the machine, the preconditions for an organization to
use such as system "flexibly" include people in the organization having the training, skills, and
experience to use it effectively and the desire to use it to its capacity. Then, if someone says
"we should produce product 'a' instead of product 'b'", it is not seen as an issue. If however, the
machine, skills, training, or experience are not in place, or if the desire is not there for
whatever reason, the person making the request will rapidly be perceived to be acting
'politically' in some sense of the word.

Where does flexibility come from?

In chapter one, I argued that once people decide to act in exceptional circumstances,
three things need to occur: sense-making, problem-solving, and implementation. In
unexceptional (routine) circumstances, the decision to act is trivial and only implementation is
needed. However, if things are routine, the actor/s won't feel a need for room to maneuver.
Therefore, the exceptional case is the important one, and the three steps are needed.
Given three stages, flexibility can be expressed in one, two, or all three of them.\(^1\) We can imagine organizations which are tremendously good at working out what is going on in their competitive environment, but which always seem to respond the same way, irrespective of what they find. General Motors in the 1980's springs to mind as an example. Similarly, some organizations are very good at developing multiple responses to a given stimulus. For instance, engineers are taught several different techniques which they can use to solve mathematical problems. They are taught graphical (drawing the relevant equations), analytical (solving the equations), and numerical (approximating a solution with a computer) techniques. Finally, given a single solution, some organizations have many ways of implementing it. For example, a firm might have a very narrow way of determining that it needs to have a layoff, and who needs to be laid off, but can be very creative in determining when the circumstances call for a meeting, a memo, a video of the CEO announcing the layoff, or meetings with individual people.

An organization which is flexible at a given stage will be able to generate many options for the carrying-out of that stage. The notion of "many options" clearly has a quantitative dimension -- the number of options it can develop -- and a qualitative dimension -- the extent that the various options differ from each other.

But how do we know how many options an organization will be able to generate at a given stage? And, more to the point, what is the relationship between the form of the problem, the form of the organization, and the number and variety of options the organization can generate? The literature on organizations suggests two approaches to answering this question, which I will label as the "routines" and "bounded rationality" approaches. Although I will present them as separate, they are in-fact complementary. That is, both approaches could be used to explain any given event in a given organization at a given time. However, each approach provides a different lens which highlights different aspects of the problem. Therefore, in certain situations, one approach has more explanatory power. I will treat the approaches as if they were separate and will not elaborate upon the relationship between them.

The "routines" approach to navigating the three stages.

The key idea with the "routines" approach is that organizations act by executing well-defined routines (Nelson and Winter 1982; Zucker 1988; cf. Schank and Abelson 1977). Given a set of input stimuli, the members of the organization will select a routine, or set of routines, to enact and execute. The execution will lead to a desirable outcome. An operating procedure is an easy example. Given a set of stimuli, the process operator determines that a given procedure is called for and invokes it in accordance with its written commands. As we saw in chapter 11 however, routinization also includes things such as norms and deeply embedded, basic-assumption-level-understandings (such as how to behave when conducting a conversation with someone) (see also Garfinkel 1967).

Under such a model, flexibility comes from having multiple routines which can be invoked in response to a given set of stimuli. The engineering students above provide a good

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\(^1\) As we will see below, most authors focus exclusively on the implementation stage. An exception is work examining flexibility in new product development, (e.g. Adler (1990)), which examines problem-solving.
example. The students are taught graphical, analytical, and numerical approaches to solving a particular problem because, in a given situation, one approach will be more appropriate than the other two. For example, an engineer would not want to have to rely on a numerical model when taking a quick decision on a construction site. Similarly, the same engineer would not generally trust the output of a numerical model without obtaining a rough graphical or analytical check of the answers.

The “bounded rationality” approach to navigating the three stages.

The bounded rationality approach is slightly different. Under this conception, organizational actors are much more creative. Rather than simply selecting between different, predetermined, organizational routines, they try to develop solutions specific to the problems they face. Unfortunately, they are not free to do this. Their actions are constrained, or bounded. In general, authors talk about two classes of bounds: individual and organizational. Individual bounds arise because the human brain is small and subjective, and the world is large. The individual cannot possibly acquire and process all information relevant to the problem at hand. That is, the individual faces an information processing constraint (March and Simon 1958; Cyert and March 1963).

However, the organization also imposes two constraints. First, the organization filters information (Galbraith 1974). That is, the physical and organizational location of the individual influences the information to which he or she is exposed (Allen 1977). Furthermore, the organization also imposes political bounds. If an individual wants to get the organization to do “something”, there are potentially other individuals who want it to do “nothing” or “something else”. Those other individuals can constrain the individual’s capacity to act.

Notwithstanding, individuals in some organizations have better information and more freedom to act than in others. In part, we can infer from chapters 10 and 11, that these freer people live or work in organizations in which attribution errors are minimized and practical rationality is encouraged (i.e. less politicized organizations). However, that is not the whole story. In this section, I argue that flexible organizations can also differ from their inflexible counterparts by containing multiple pools of resources available to the actor for completion of the given task. In particular, if the binding constraint tends to be informational, then the individual who has access to multiple sources of information is likely to be more effective. Similarly, if the barriers are political, and we define politics in terms of competition for resources, multiple pools of resources will be key. However, as we will see in the examples below, the argument is not simply one about differentiation. Rather, the mere presence of the additional information sources and resources pools changes the organizational dynamics.

An example of multiple sources of resources: Capital allocation at FLECSOCO

To exemplify the notion that flexibility also comes through the possession of multiple pools of resources, I will discuss capital allocation at FLECSOCO, which I studied earlier (Cebon 1993). If we read the literature on capital allocation in corporations, we find that, in general, it is a highly political process, and those politics lead to inefficiency in certain classes of investments. Energy conservation investments provide an interesting example. Ross (1986) found that corporations with centralized capital allocation tended to under-invest in energy conservation to a huge extent. The mechanism by which this happens was very similar in the five or six cases I have investigated personally, read about, or discussed with other researchers. Most corporations have a single system for allocating capital. That is, while there may be some sub-categorization on the basis of project size, and the level to which the
project must rise in the corporation for approval, all projects follow the same route through the corporation and are assessed by the same people. On the way up for approval, people attempt to prioritize projects. Generally, power and influence have as much, or a greater impact on what goes up for approval than objective measures. Then, in many corporations, the financial staff will routinely trim 20% from any capital allocation because they believe it creates efficiency. As a result, projects have to be cut back in scope. Again, this process is highly political.

Enter the energy manager. For a number of reasons, this person tends to have relatively low power in most corporations. In particular, minor savings are rarely strategically important or sexy, and good projects can rarely be found without the cooperation of a number of groups in the organization (Cebon 1992). Not surprisingly, very few energy projects get approved by corporate decision-makers, and those few often get cut after approval. For example, at a meeting to allocate capital within Highplant, the plant leader for the laboratory (the least powerful of the five) wanted to spend $8,000 to save about $20,000 annually in energy. However, the other plant leaders vetoed this, saying that cash was too tight. Their annual budget ran to millions of dollars.

FLECSOCO had a capital allocation method which overcame this problem. Instead of having one or two pools of capital, the corporation had six. Each pool had different criteria for allocating money. So, the “environmental capital” pool would examine the amount of waste reduced and compliance issues. The “big new capital” pool looked at the strategic importance of the proposed works in addition to the financial performance. The “small capital” pool had its own algorithm, as did the “big quality and maintainability” pool. On the surface, this all seemed well and good. If someone had an environmental project, they would put into the environmental pool. Big capital additions would go to the big capital pool, etc. The definitions for each pool were overlapping so that people could often slot projects into one pool or another. However, once a project was in a pool, people were locked into a relatively rigid set of allocation rules.

It makes sense to examine the impact of such a system in two stages. First, let’s put aside a lot of the strategic issues, and just consider the impact of having multiple pools. The multiple pools enable senior management to specify much more narrowly the domain across which a potential project will be assessed. As a result, objective assessment criteria are much more likely to determine which projects are funded since the projects are very similar in other respects. So for example, energy conservation projects which were advocated on the basis of their financial performance would be compared to other projects advocated on a similar basis.

As a second stage, consider the strategic aspects of the FLECSOCO system. There are two sets of actors to consider. The first are the senior managers who allocate money to the pools. The system gives them high levels of macro-level control at the expense of micro-level control. They have no control over which projects actually get funded. While this may appear to them to be a disadvantage, it prevents the problems of micro-management and politicized interventions from above. But, they can control the general thrust by changing the amount of money which goes to a given pool, change the decision-making algorithm for a pool, or by creating ad hoc or permanent new pools as necessary. For example, FLECSOCO created its “environment” pool in the late 1980’s to ensure that environmental compliance projects were funded. The second group of actors is the people who want to have projects funded. The

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2 At FLECSOCO, very large projects (i.e. those which will take up a significant portion of the budget) tend to be negotiated outside the capital allocation system.
multiple pools allow the individual actor to be strategic in describing his or her project. At FLECSOCO, it is quite common for people to combine, break apart, or redefine projects to fit the needs of different pools, depending on where they think resources are available. We will see the ability of the multiple pools to prevent politics much more clearly when we consider flexibility through multiple sources of information, rather than capital.

There is a very interesting example of flexibility through multiple resource pools comes from the study. In this case, the resource being allocated was legitimacy, and the group wanting the legitimacy was the Transitech energy conservation group. In the course of the study, it changed its self-definition twice. With each change, the group also changed its alignment to groups at the apex of the corporation. In the beginning, they saw energy management as a problem of power station reliability, and the need to upgrade facilities so that the plants could be served well. Then, they changed alliances and started to see the importance of energy conservation as a way of saving money in the recession. Finally, they aligned themselves with the corporate environmental group, since that group had become more powerful than the manufacturing people. After they had consolidated their position there, they broadened it, first by sponsoring a crash cost reduction through energy conservation, second, by bringing the manufacturers back on board, and finally giving advice to customers (and potential customers) on the way to construct a corporate energy strategy. This last move brought in the businesses. The point is that a definition of energy conservation as any one of these functions alone: reliability, cost, or environment, would have doomed the program. The strength of the effort lay in the ability of the team leaders to shift the definition of energy management to suit the politics of the times.

This argument and organization theory’s versions of flexibility.

In the following two sections I integrate this argument with the existing literature. In this section, I will examine two popular theories found in the organizational literature which could account for flexibility in organizations. I will demonstrate that they are inferior to the one presented here. In the following section I will examine models of flexibility found in the “flexibility” literature, and show that the argument here can incorporate them.

Flexibility as slack

Organizational theorists have traditionally equated flexibility with ‘slack’. Slack is unallocated organizational resources (March and Simon 1958) which are used to accumulate solutions to potential problems. When the problems actually emerge, the organization searches through its storehouse of solutions, and plucks out the appropriate one (March and Simon 1958; Cohen, March et al. 1972). Clearly, slack is one way of providing flexibility, as I have defined it above. However, there are two problems with using it. First, it is an extremely wasteful use of resources. If the organization is constantly generating solutions in a random manner, then, by definition, most of these are wasted. Second, unutilized resources tend to be generators of political activity in a corporation. It is much easier for people to build empires if there are spare bricks lying around. It is much easier to avoid people, or not learn how to trust them, if you aren’t dependent on them. As such, slack is as likely to inhibit flexibility as to create it.
Flexibility as redundancy

Flexibility can also be provided through redundant systems (i.e. instead of having differentiated resource pools, they are identical). For example, if there is a standby pump for every duty pump, it is much easier for people to vary the quality of maintenance they perform. The two problems here are that this sort of flexibility is very expensive and that it isn't very flexible. The second pump doesn't really enhance the organization's ability to generate variations. It simply permits variations in the quality of the inputs (maintenance in this case). As such, it is probably providing capabilities that are better provided in other ways. However, there are situations where such redundancy makes a lot of sense, though usually in the pursuit of reliability, not flexibility (e.g. redundant power supplies in nuclear power plants, or redundant computers in banks).

This argument and the flexibility literature

In this section, I will demonstrate that the propositions advanced here can account for all of the types of flexibility discussed by other authors. There are two ways to conduct such a test. A strong test would be to find examples of flexibility and determine their organizational origins, as with the FLECSOCO case above. A weak test would be to find examples of flexibility and see whether the propositions advanced here can provide a plausible explanation for the phenomena observed. In this section I will carry out such a weak test by content analyzing abstracts retrieved from "Sociological Abstracts". I conducted a citation search for all articles with reference to "organization" and "flexibility" (with all their appropriate variations in spelling and suffixes). This yielded 727 articles in five years, spanning a large number of countries and intellectual traditions. Of these, about 80% were relevant to this paper. In addition, I obtained a review article on flexibility in the operations research literature (Fine 1993) and a dissertation (Suarez 1992). I content analyzed the abstracts for the first 150 articles obtained in the database search, and found that the authors used "flexibility" in two different ways.

Innovations as flexibility

The first group of authors were those who claimed that the innovations they were discussing represented increases in the flexibility of the firm. A good example might be the use of flexible machine tools, or the move to flexible hours through variable length working days. Other examples included flexibility as being able to meet a variety in the demands of clients, the creation of health insurance policies with more flexible eligibility requirements or services covered, large networks of small, flexible-specialist companies (flexible specialization) (Piore and Sabel 1984), people's abilities to change jobs in a given workplace or between workplaces, flexibility as temporary workers, home-workers, and contractors, the flexibility accorded by

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3 In the others, "flexibility" and/or "organization" were secondary descriptors for the paper.

4 I stopped at 150 because I wasn't learning anything new after 100. The aim was to discover the types of flexibility discussed in the literature, not the quantities of each type.
family ties, the flexibility that comes from creating business and financial complexes, and “the French system of worker pools, whereby workers are given the chance to increase or decrease the number of hours they work each week as long as they maintain a minimum balance of hours & as long as the pool can satisfy the company’s labor needs” (Guelaud and Lanciano 1991).

To incorporate these into my model I have to show two things. First, that the changes they describe can be understood in terms of my definition: namely an increase in the capacity to move between alternatives at low transition cost. Second, I have to show that the increase in capacity comes from an increase in either the number of routines or the number of resource pools accessible to relevant actors in the organization. It is probably sufficient to show that these two conditions are satisfied for the flexible machine tools, the variable length working days, the health insurance policies, the use of temporary workers, and flexible specialization.

Flexible machine tools meet the definition because they have the capacity to make multiple products. They make these different products by executing computer programs, which are essentially production routines. Therefore, the move from specialist to generalist machines involves increasing the number of production routines available. If you give people control over the length of their working day, you allow them to go from no routines for deciding which hours they will work, to one (which they choose). If an insurance company makes the eligibility criteria for a health plan “more flexible”, essentially, it increases the size of the pool of conditions for eligibility. Then, it creates a routine, or set of routines, for pulling appropriate subsets out of the pool (and rejecting inappropriate subsets). Finally, the use of temporary workers (or family members) enables companies to draw from multiple labor pools: high price, high skilled permanent employees, low skilled contractors, etc. With flexible specialization, the flexibility is achieved on two levels. First, at the firm level, the idea is that firms are small so they are not inertial. Therefore, they can change products rapidly (by means of craft skills, computerized machines, or whatever). Second, at a meta-level, each industrial district acts like a large “firm”, with the individual firms acting as resource pools from which a lead company can draw. Which firms are used for a given product depends on their particular attributes. Presumably complexes of businesses and financiers are more flexible than large banks in much the same way.

Innovations as the source of flexibility

The second group of authors argue that there are a series of innovations which, if carried out successfully, will lead to flexibility. For example, Osterman (1994) argues that the adoption of particular workplace practices such as “total quality approaches” or “team based management” leads to an increase in flexibility in the organization’s performance in the product market. Workplace practices provide the only important case in the sample.

To incorporate this into my model, I have to show one of two things. Either the change corresponds to the addition of routines or resource pools to the organization, or the change involves putting in place an infrastructure which removes blockages to routines and pools which lie latent in the organization.

Without going into too much detail, these practices do increase flexibility in the way proposed. People acquire skills so they can run the machines at their capacity. This is a case of removing obstacles. Also, people work in teams to facilitate problem-solving. This is an arena where multiple sets of skills and perspectives (i.e. multiple pools) facilitate rapid finding of solutions. The capacity to solve problems allows the firm to provide a more differentiated set of products to customers. This meets the definition. In addition, many of the changes in workplace practices are not about flexibility as I have defined it. For example, quality circles
are used to facilitate innovation (which we have excluded from the definition).

**Flexibility at the two plants**

In this latter half of the chapter, I will simply give three sets of examples which show the way in which structural differences between the two sites led to differences in flexibility. In the first group are examples where one plant is more flexible than the other, and that is a good thing. In the second, one plant is less flexible than the other, and that is a bad thing, and finally, in the third, one plant is more flexible than the other, and that is a bad thing. The aim of these last examples is to emphasize that flexibility isn’t always a good thing, but that it is only better when appropriate.

*Where one plant is more flexible than the other, and that is good.*

**Maintenance scheduling at Wideplant as flexibility through multiple routines**

Consider the performance of maintenance in area ‘A’ at Wideplant as an example. Graham, the production coordinator, was constantly amazed by the way in which the people coming to days seemed to ‘grow’. He told me, on several occasions, that you could almost see the transformation occurring. People came to days and rapidly acquired a new understanding of the way the place worked, and what it took to make ‘compound’. And, he pointed out with pride, you could really see it in the maintenance numbers. Since they started the rotations, the ‘mean time between failures’ for the pumps had doubled, but maintenance expenses had dropped. This indicated clearly that they were really getting the preventative and predictive maintenance done effectively to avoid mechanical problems.

Unfortunately, his argument didn’t accord with my observations in the area. In particular, while I had seen people ‘grow’ in the way he described, I didn’t see it translating into better maintenance. There were two ways in which maintenance was supposed to be scheduled, and neither seemed to be working. First, the ‘site’ point who was working days was meant to walk the buildings looking for jobs which needed to be done and talking to people to milk their observations. However, as the mechanic on the ‘change task team’ had noted, it takes a fully-trained controller about three months to learn how to do that effectively, unless they know the buildings and equipment intimately and have enough self-confidence to really assert the need to perform (or not perform) particular maintenance jobs. By the close of the study, the rotation period had been reduced to three months. Not only did this mean that it would be hard to ever have a well trained site point, but the mechanics were no longer interested in providing the necessary training (see also chapter 6). It is hard to see how the requisite skills would emerge.

Furthermore, the current point was a trainee controller with only three years’ experience. The mechanics claimed that he couldn’t possibly know the building well enough to be able to spot equipment which needed to be maintained, unless it had already broken down (which contradicts the empirical data and the aim of the exercise). To add insult to injury, this particular controller was fairly young, and didn’t yet have the wisdom to realize that he didn’t have the skills to do the job effectively, or the interpersonal skills to get the site points on the crews to do it for him.
Second, the site points on the crews were meant to help perform the job. However, they weren’t jumping into the breach. Even if he had sufficient interpersonal skills to elicit their help normally, they wouldn’t have been sufficient at the time of the study. Morale was low and people didn’t want to extend themselves too far beyond minimal work requirements. So, very few people were looking for extra work. Furthermore, as we saw in chapter 8, there were skill and attitude differentials across crews. So, the general desire to be helpful would need to be high before the two laggard crews would have provided assistance. Finally, in this sort of a situation, there are norms of reciprocity. When this particular day site point was on shift he hadn’t been extending himself. When he went to days, they owed him nothing.

So, how could this be? It seemed that the production coordinator had it wrong. While the organization was more flexible than a traditional organization, in that there were two different procedures for doing the scheduling, neither seemed to be working. The personal growth through the point work wasn’t leading to the maintenance being scheduled and the points on the crews were not helping out. However, it turns out that the organization had a third, informal, routine for maintenance scheduling. The maintenance was being scheduled, and with tremendous expertise, because the mechanics were doing it.

Some months earlier, the mechanics had attended a training session under the aegis of the corporate maintenance initiative. There, they had learned the value of predictive and preventative maintenance. Over time, management hadn’t been replacing retirees, so the number of mechanics in the area “A” mechanical shop had been declining. Now, they only had six people, including an apprentice, an insulator who did no mechanical work, and a controller on his or her secondary-skills rotation. None of these was equivalent to a full mechanic. Furthermore, the planning job took one person. In effect, they had about three mechanics' worth of people for all the mechanical work. Following the predictive and preventative maintenance training, two of them concluded that they could only complete their work with the available resources if they could avoid mechanical breakdowns completely. Therefore, convinced by the training, and applying a principle which they called “intelligent laziness", they decided to make sure that all the predictive and preventative maintenance was performed as the first priority. So, completely unbeknownst to anyone in production management, two of them made sure that they each walked the buildings from top to bottom at least once a week looking for early signs of breakdown. They would then feed the jobs to the site point. When they received the jobs back, or any reminders from the computerized routine maintenance scheduler, they would make sure that the preventative and predictive work received the highest priority and was completed.

While it is possible to see this as a case of tremendous dedication, it is important to realize that the work organization made it possible for the mechanics to take this initiative, even if in an unplanned way. Because the mechanical shop was run virtually without a supervisor, the mechanics had the freedom to spend their time walking the buildings, and sufficient access to the site point and the jobs to control the flow of work. At Highplant, they would have had neither. These roles would have been taken by the supervisor and various day staff members, and so the mechanics wouldn’t have had enough control over their work to influence the process.

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5 Their principle of “intelligent laziness” is that everyone should try to do the minimum amount of work possible, while performing their job well.
The Widesite union as flexibility through multiple information sources

The union served two very interesting informational purposes at Widesite. First, we saw in chapter 11 that there is a risk, at Wideplant, that people will not follow the rules when they should. Instead, the pursuit of practical rationality can lead to major compliance failures. The union served to insure against this. Second, the union provided vital information to the senior managers who were trying to orchestrate the change effort.

Many members of management found the union extremely irritating. They found its relentless -- some would say mindless -- pursuit of legal compliance, particularly through the joint health and safety committee's monthly meetings and audits, and through incident investigations, perpetually frustrating. There were two reasons for this. First, the committee was a source of institutionalized power which the union exploited in petty ways. All the joint health and safety meetings were conflictual and unpleasant because of constant battles over irrelevant pieces of turf. Second, and more interestingly for this discussion, the committee provided a legitimate, and very powerful, forum in which compliance problems could be raised. Initially, the union was over-zealous and would come out of its audits with huge lists of compliance failures. Management generally found this distasteful because issues were often trivial (mis-labelling of equipment, etc.) but expensive to rectify. However, once problems were identified in an audit, management was generally under a legal obligation to fix them.

Over time, however, the committee settled down. Then, the union, both through audits and through people bringing concerns to their stewards, was able to force management to deal with significant compliance problems whenever they arose. For example, I was able to find out about the safety shower problem and the laboratory where the manager decided the employees didn't need hazardous materials training (chapter 11) because these issues had been brought up (and dealt with) at the joint health and safety committee meeting. In contrast, I have no reliable way of knowing the extent of these sorts of problems at Highplant.

It is important to realize why the joint health and safety committee fulfilled an important role here. It is not that the union cared about safety and management did not. Rather, the union was in a much better position than senior management to make sure that the law was being complied with. First, while management had objectives of maximizing safety and minimizing cost -- which were often in conflict, at least in the short term -- the union did not. Its interest was to put safety first. Therefore, it could be unequivocal in its claims. Second, and more relevant to the argument here, the union was in a much better position to monitor plant management's performance than was site management. While site management generally had to rely on reports which were filtered by several layers of managers and facilitators whose performance it was trying to monitor, the union had direct and independent access to what was going on in the workplace. That is, its information gathering system was much more diffuse, much more "local", and much more direct. While there was a chance, through attribution errors or whatever, that the union would mis-report issues, it still brought those issues to the surface for discussion.

Given the presence of the union performing this function, we expect management to

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6 Notwithstanding, the more sophisticated union members would acknowledge that the demands they made for safety were moderated by their understanding of the particular business’s financial situation.
change its behavior. We expect a manager who knows that the union will expose any attempt at obfuscation to always be honest. This reduces the amount of work the manager’s supervisor must do to find out what is going on. That is, behaviors throughout the organization change simply because the union is present, and the amount of politicking declines along with the information asymmetries.

The role of the union in the change effort was very similar. For senior managers trying to orchestrate a large-scale change, one of the big problems they faced was a dearth of high quality information about what was actually going on in the workplace. They could only walk into a workplace and ask questions rarely (such as on a manager’s safety audit) without treading on the toes of people under them. In such a situation, the answers they received to questions might well be flavored by such processes as the selection of operators and mechanics who understand the importance of giving a good message to top management. If, alternatively, the senior managers have an “open door” policy, they are likely to get more information about issues in the workplace, but again, that information can be sparse because people don’t like to go ‘around their bosses’, and be excessively negative.

If the union is reasonably supportive of the change effort, however, as was the case at Widesite, it can provide very reliable information to management. The senior members and stewards in the union work in the production areas are receiving constant information from the production workers directly about their feelings, thoughts, and concerns. This provides an important device which enables managers to monitor the change process.

Attribution errors by Wideplant controllers as flexibility through multiple information sources

The second example of flexibility through multiple information sources concerns attribution errors among the Wideplant controllers, and the way they may have actually facilitated, rather than hindered, safe change. As we will see later, we expect people to buy into the new work organization at different rates. Therefore, we expect variance in the extent to which people see the world with the “desired eyes”. We expect the people who have not bought in to make ungenerous attribution errors about people’s motives. Surprisingly, this can be an asset.

We saw in chapter 10 that one of the Wideplant controllers made attribution errors which bordered on the paranoid, assuming that virtually everything that happened had a sinister meaning. This provided a tremendous benefit in two ways. First, we saw in chapter 11 that there is a risk, in an organization such as Wideplant, of people becoming overly zealous in their desire to abandon rules in favor of principles. This can be hazardous if they don’t understand the system they are managing as well as they think they do. As would be predicted by the theory, every time a manager asked a worker to do anything which could be construed as a breach of the rules, this controller would raise hell in the morning meeting, or with management directly. As with the union, this was a constant source of irritation to many members of the management staff. It meant hours spent justifying their behavior to someone who would never be satisfied. However, it was an effective device for ensuring attention to

7 Clearly, this can only be a theoretical prediction since there is no obvious comparison group. Furthermore, I have no data examining the actual transmission of information at the two sites directly. However, conversations with some senior managers at Widesite would suggest that the conjecture, while theoretically based, was borne out.

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compliance problems, and that the organization didn’t stray too far from acceptable behavior.

In addition, this constant barrage of complaints and accusations helped the change effort directly. As we saw in chapter 10, attribution errors come, in a large part, from people putting their own subjective interpretations on ambiguous information. Through his complaints, virtually all conceivable questions were discussed whenever they arose. This meant that people were generally fairly clear about what was going on, and so the general level of ambiguity dropped. Therefore, we would expect that the change would be smoother as a result.

*Multiple information sources as a vehicle to safety*

In area “A” at Wideplant the procedure for performing a particular unloading operation was inadequate. In particular, in Winter, if people wore all the gear mandated by the procedure, they would not be able to see the job. Unlike most procedures in the area, this one was not written with consultation of the controllers, and when one of the controllers complained, the engineer rewrote it, again without consultation, and this made the process worse. I observed in some safety meetings that when people brought up concerns of which the facilitator was already aware, the facilitator would tend to avoid confronting the concerns. A controller waited two years until the production coordinator attended a safety meeting, and feeling relatively safe to speak up, raised the issue again. The production coordinator was alarmed, and said that he would deal with the issue. In other words, the safety was created by the production employees having an alternative vehicle for their concerns -- the production coordinator, in addition to the facilitator.

There were two other, virtually identical, cases in the dataset. One involved a controller bringing in the site manager because he thought a procedure wasn’t being implemented properly, while the second involved someone taking an issue to the area B-C production coordinator.

*Flexibility to flatten the peaks.*

Finally, both plants had very similar devices for flattening the peaks of the workload. At Highsite, in a crisis, the foreman would help out. This was particularly true in other plants on the site, much more than in Highplant itself. At Wideplant, in contrast, the people who were working on a day rotation would often find themselves in overalls helping out in the plant because some or the workload was abnormally high.

*Where one plant is less flexible than the other, and that is bad.*

*Rotations and flexibility loss*

Without doubt, the most contentious aspect of the new work organization at Wideplant was the rotations to days for administrative work and secondary skills. We saw in chapter six that there were five classes of reasons why the controllers generally disliked them. First, there were two key technological differences between 'compound' manufacturing and the prototype area in which the work design was developed this meant that the technical and customer-driven motivations were not there. Second, although people grew through the work, they did not like it. Third, there were strong group norms against liking it. Fourth, they thought their pay declined if they worked days, and finally, the move to days was extremely
disruptive of their life outside of work.

We will focus on the last reason, which was the one articulated most clearly (after the supposed loss of pay). The key thing to note is that the rotation system dramatically reduced the amount of flexibility in the work allocation system. In particular, with the old system, there were two classes of jobs the operators could work, shift jobs and day jobs. The day jobs could be used to squirrel people away, as necessary. If someone started to lose his nerve with the process, or had a spouse or child with a disability that required them to be home every evening, they could take a day job. Similarly, if someone wanted the freedom which comes from doing shift work (you get a lot of free time because the shifts are 12 hours long), they could take a shift job. With the new system, both of these options disappeared, and so all of the contradictions and problems which were previously hidden by the flexibility of the work allocation system had to be managed actively.

The rotations caused a very similar flexibility loss in the staffing of the plant fire crew. A small group of controllers would spend a day a month at fire training so they could be ready to fight any chemical fires on the plant. However, with the advent of the rotation system (especially coupled with a desire to reduce overtime rates) a host of problems kept cropping up. People didn’t get the training they needed, or a shift would discover that there was no one on site who was qualified to be the captain of the crew, or someone would work shift on overtime (from working days) and would be asked to be on the fire crew that night, when they hadn’t had the appropriate training.

_Prototyping the Highplant equipment_

When they started up the new operation, one part of the design hadn’t been finalized. One of the engineers wanted to prototype the new design on the old production facility (the alternative source of resources) before it was decommissioned and the new one was started up. Because they thought it would be an unnecessary cost, his supervision over-ruled him. As a result, the prototype was installed on the new facility. Unfortunately, it was a constant source of operations difficulties. (If it hadn’t been I doubt the engineer would have remembered the incident, let alone told me.)

_Where one plant is more flexible than the other, and that is bad._

It is very easy to assume that flexibility is a good thing. However, for every gain in flexibility, there is a reduction in micro-control by those who designed the system. Here, I will give three examples. In the first one, the actor concerned was trying to exploit flexibility (in the form of multiple rhetorical arguments) to avoid spending money. In the second and third, it was a lack of flexibility which prevented problems from occurring. The point here is not to argue that the organizations should be perfect. Rather, it is to show the role of flexibility in removing top management control over the organization.

_A plant leader tries to avoid spending money_

I attended a meeting where a group of plant leaders was trying to allocate some capital. One of the plant leaders at the meeting was trying to avoid spending any money, since there was a cash flow problem in the plant, and the moneys were all being requested for projects which would have no financial return (see also Jackall 1988). As the various project proposals came up, the plant leader would reach into a rhetorical grab-bag for reasons to not fund the
projects. This included invoking (completely incorrectly) a corporate standard which stated that some backup equipment wasn’t needed, when common sense indicated that it definitely was, and stating that they should use a risk/benefit approach to decide whether to put spill containment around a tank (when the corporate rule was unambiguous about there being an absolute standard). In this case, the plant leader was trying to inject as much flexibility into the process as possible (through reinterpretation of the rules). From a corporate standpoint, it was fortunate that the room to manoeuvre was very limited.

Although it doesn’t warrant too much space, there were other examples of similar behavior. In particular, at one Highplant morning meeting, the area specialist tried (unsuccessfully) to argue for a change in the definition of some Best Operating Parameters (BOP’s) so that the plant’s performance would improve. Again, it was the lack of flexibility that prevented problems arising.

Formalized procedures force certain types of communication.

The final example has a different flavor. The particular example from which it is drawn involved the procedure an electrical contractor had to follow before starting work. The procedure was very strict and required the contractor to get approval from particular people. Those people, before they could give their approval, had to have particular conversations with other people. As a result of those conversations, all the relevant people knew that the work was going to go on, and the chance of issues slipping by unnoticed was very low. If the contractor had had any more flexibility, there is a good chance that these other communications processes, which were vital for safety but invisible to the contractor, would not have been induced.

Conclusion: Flexibility and organizational performance

So, a flexible organization is one that has many routines to choose from in the performance of a given task or many resource pools from which people can draw. However, a flexible organization is not necessarily effective. For each of the three stages of action -- sense making, problem solving, and implementation -- we can posit that there are some dimensions along which organizational performance can be measured. These dimensions make up a solution space. In this solution space, there are two domains of interest. The first is the domain which represents the range of solutions the organization can produce without people being perceived as acting politically. The size of that solution space represents the flexibility of the organization. The second domain is the range of solutions demanded by the environment. There are two measures of organizational effectiveness. The first is the quality of the match between the solution space and the demand space. That is, is the organization flexible in the right way for the problems it faces? This is illustrated in figure 12.1. For example, not even three analytical techniques will help the engineers above to understand the social sides of the problems they solve.
Figure 13.1 The relationship between flexibility and effectiveness

The second important property is the capacity of the organization to match its solutions to particular environmental demands.\(^8\) To match particular demands, people must know which routine to pick or resource pool to draw from when faced with a particular problem, or be effective sense-makers and problem solvers to develop a strategy for action. Pentland (1991) examined the first approach and argued that knowing how to pick an appropriate routine (or in his case how to decide which of a number of approaches to invoke when fielding a telephone query) forms the basis for organizational "knowing". That is, the organizational has a meta-level set of routines, which he calls 'moves'. Participants have a complex set of heuristics for choosing between moves. Organizational capacity is determined by the quality of that heuristic and the quality of the routines invoked.

*Flexibility and performance, more directly*

From the preceding discussion in this chapter, it should be clear that flexibility provides a double-edged sword in the determination of performance. On the one hand, by creating flexibility in the way I have described it, the organization facilitates a lot of innovative outcomes. If the organization is operating in a domain where such innovative

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\(^8\) Were it not for a bug in this word processor, I would include shading to show that -- in the flexibility rectangle -- the organization is more capable of producing some solutions than others, while -- in the demands rectangle -- the environment places more value on some outcomes than others. Effectiveness is then measured by the quality of the match, rather than by the mere existence.
outcomes are important, then flexibility can be a huge asset.

The case of the mechanics scheduling the maintenance is a good example. Once when I was doing some research on university energy conservation (Cebon 1990) a physical plant manager explained his 20/80 rule to me. That is, as he saw it, 20% of the people in an organization are motivated, 60% do their job, and 20% are free riders. If a task is critical, and many people have access to that task, the chances of one of the 60% stumbling on a critical task and doing it, or one of the 20% having the ability to do a critical task that everyone else has missed, is much greater. This is essentially what happened with the maintenance scheduling.

On the other hand, as management gives people more options for the fulfilling of a task, it gives up control over task performance. Therefore, in situations where control is critical, flexibility is a bad thing since behavior will start to look more chaotic. For example, plant designers want very little flexibility in the operation of certain parts of the process because it could be dangerous if people took too much initiative.
13. Histories of change

The remainder of the dissertation will discuss the issues surrounding organizational change in the two plants. As I said in chapter one, both plants had change initiatives in place at the time of the study. Wideplant was trying to continue the implementation of its organizational system, while Highplant had two thrusts. On the one hand, there were pressures from below, and probably from above also, to implement the Wideplant organization. On the other hand, the site manager was brought in with a mandate to improve safety performance, and he believed firmly that improved performance was created by giving people an unambiguous incentive. Implicit in such an approach was the creation of a fairly authoritarian work environment.

This part of the dissertation asks what it means for an organization to change, what the causal processes for change are, and what the barriers to change are. In this chapter, I will present the histories of change until the time of the study. In the next, I will discuss what it means, in terms of the categories I used in the first two thirds of the dissertation, for an organization to change. Following that, I will discuss the sorts of strategies I observed people using while they tried to create change. That will be followed by a description of the barriers to change I observed during the field work. Some of those barriers are linked to safety performance, but they have already been discussed. The final two chapters will discuss the role of sense-making activities in organizational change, and will look at the sense-making around, and impacts of, four accidents -- two at each site.

Highplant: change from 1980 to the time of the study

Highplant began its change effort by eliminating two layers of supervision. Of these, the more important was the elimination of the second line supervisor, the layer between the supervisor and the plant leader. Each plant had had two second-line supervisors, one of whom had risen from production and the other of whom was an up-and-coming engineer. This was a dual role. On the one hand, the pair managed day-to-day operations, while the plant leader looked over their shoulders and managed longer-term issues. On the other, the older supervisor would develop the young engineer's managerial skills prior to promotion to plant leader. With the change, most of the day-to-day functions were given to the area specialist and the planning and scheduling supervisors (see chapter 6). The other layer eliminated was that just below site manager.

The major problem which the first change caused was a discontinuity in management training. In both straight technical plant engineering jobs, the engineers had no direct supervisory responsibilities. If they were promoted from one of these jobs to plant leader, they suddenly acquired anywhere from ten to 70 supervisees. This was a huge jump, and many operators, engineers, and foremen complained (for different but predictable reasons) about this change in the training system. “Support engineer” positions were created to alleviate some of the problems, though they still didn’t involve direct supervision.

Second, people were given ‘organizational effectiveness’ training. This had two parts: understanding how to think about the organization, and understanding how to work together.
Their personal guru for the former was Charles Kron. Using Kron's model, they attempted to teach people how to think about the organization and its problems. Kron had an unusual pedagogical philosophy. He deliberately obfuscated the problems to force people to wrestle with them. He used a number of devices for doing this, including making up his own terms, giving conventional terms his own meanings, speaking in non-sentences, and constructing models with a huge number of variables. As a person with considerable expertise in organizational design, I found most of it incomprehensible. It is not surprising that one manager noted that:

Organizational effectiveness provided abstract, philosophical tools for employees to use on their jobs without specific, concrete examples. ... This was too nebulous for many. Employees said, 'You've given me these thought processes, now what do I do with them? How do I apply them to my everyday job? Organizational effectiveness wasn't real enough for a lot of people.' (American productivity center 1987)

In the second part of the training -- interpersonal skills training -- people would have large 'open, honest, and non-defensive' meetings. It seems that these meetings had two problems. First, they were destructive. People with limited power, such as process operators, would use the protection afforded by the meetings to "bitch and moan" about problems in the plant. However, these issues were rarely resolved and no one created an environment in which the people who complained about the problems ever took responsibility for finding the solutions. As a result, there were long meetings full of recrimination and blaming. Second, these meetings took an inordinate amount of time. Decisions were rarely made and so people felt that nothing was achieved. This was exacerbated, from what I can gather, by the fact that the subjects discussed in these meetings were divorced from specific problems at hand within the plant. Because participants were not constrained by the task, they tended to digress.

Third, management radically decentralized responsibility for key aspects of the plant's operations in three ways. First, primary responsibility for many site-level functions (e.g. safety management) was moved from the site into the businesses. The individual process areas were given much more leeway for the interpretation and implementation of corporate rules and objectives. Unfortunately, conflicts between objectives, and how they should be managed, were not resolved. So, for example, as safety was moved into the businesses, people perceived a message that "safety is just as important as profitability", as opposed to the traditional message that "safety comes first". As conflicts between safety and productivity were managed, safety management became significantly less vigilant.

The second type of decentralization was a change from foremen to 'supervisors'. While foremen needed to be functional experts, supervisors did not. Process operators and mechanics were expected to make their own operational decisions. This aspect of the change was still being pursued at the time of the study. There were problems, however. Supervisors no longer felt they could tell people what to do or hold them accountable. Predictably, lazy people tended to defer non-urgent jobs like cleaning the plant, or inspecting equipment. Similarly, people tended to not report problems and push difficult jobs onto the next shift rather than do the work themselves. As a result, the rate of exceptions increased. By the same token, some operators complained to me that supervision never gave them the power to make decisions, and that it was all a charade (but see the discussion of similar complaints at Wideplant in chapter 9).

Tied in with the above two changes was a dramatic swing in emphasis from control to learning. Unfortunately, the organization did not work out how to juggle the conflict between holding people accountable for poorly conceived actions and finding causes of events. Therefore, they swung from holding people accountable to an high emphasis on the non-human causes of events. As a result, everything that went wrong tended to be blamed on 'design', more and more
layers of expensive protection was built into systems, and little was learned.

The third type of decentralization was the movement of a lot of strategic functions down to the shop-floor level. While people did this relatively competently, it consumed an inordinate amount of time at the expense of more mundane work.

_A quality focus_

In the mid-1980’s, the site changed landlords to a different business. With this came a change in site-level human resource objectives, and particularly, a ‘total quality’ program was introduced. The quality program had three major objectives:

- A strong emphasis on customers, and meeting mutually agreed upon requirements for them,
- Continuous improvement,
- Employee involvement.

Organizational effectiveness was rolled into the new quality program as one of its eleven components, the official vocabulary changed, and people attempted to implement the new program.

Rather than cover each of the eleven components, I’ll discuss only two aspects: employee involvement and suggestions for improvements. This program was sufficiently recent that these elements’ residues were still visible in the plant at the time of the study. Employees were asked to become involved in either inter-group activities such as the design of new processes and sitting on teams dealing with area improvements, suggestions, operating trends, safety, and the like or within-group activities such as identification of maintenance opportunities or making suggestions. As we saw in chapter 11, these were not successful. Rather, the suggestion program limped along for about four years, and the operators didn’t feel that they had a chance to really participate in the other activities.

_An experiment with self-managed teams_

By the late 1980’s, two things happened. First, the failures of the organizational effectiveness program were apparent. Second, stories of the success of the change effort at Wideplant were starting to percolate through the corporation and the ‘compound’ business organization. Highplant ‘B-C’ management decided to try implementing a stripped down version of the Wideplant organization. Over a period of a couple of years better operators were moved to one crew. Those operators learned the various administrative jobs and visited Wideplant to learn about the organization. When asked about the experiment, the operators, the supervisors, and the managers talked to me about the experience of learning the different jobs, not about any of the other aspects of the organization or its underlying philosophy. This is consistent with the argument about formal rationality in chapter 11. The supervisor began working days and the crew operated without supervision for a few months. In the meantime, a second crew started to prepare for the transition. However, just before the start-up of a major addition, and after a change in plant production leader, they requested that the supervisor be reinstated.
In essence, the experiment was abandoned for three reasons. First, there was no management support. The supervisor who had helped with the transition was the most compliance-oriented of the four (from my 'Q'-sort analysis, chapter 11) and the most directive, and therefore the least likely to empower the operators. Second, there was antagonism from the other crews. Often, the experimental crew would arrive to find a host of problems left behind by prior shifts and would be constantly blamed for problems on the shift that followed. Without effective management support, the blame stuck. Third, consistent with the discussion of formal rationality in chapter 11, managers and operators saw the new work organization in terms of its structural configuration, particularly the absence of a supervisor on shift (the least important aspect as far as Wideplant management was concerned) and the fact that the operators had extra responsibilities. There didn’t seem to be any apparent benefit other than one less body. They didn’t understand that the new work organization was meant to be the physical manifestation of a different understanding of the way work is performed. Given these three major problems plus the uncertainty associated with the impending start-up, the crew decided the experiment was too stressful and asked for the return of the supervisor.

ISO Quality certification and “Process safety management” preparations.

The final stage of organizational development occurred while the field-work for this study was in progress. The plant obtained an ISO-9000 quality certification, as did Wideplant. The important thing to note is that ISO certification has nothing to do with quality. It certifies that management has routinized as much of the organization as possible and that the plant operates in compliance with that routinization. Qualification for the certifications also served as the prototype for the implementation of the new OSHA process safety management code.

Changes at the time of the study

Additional elements of the change effort in place at the time of the study were the renewed emphasis on safety and pressures to implement the Wideplant organization. Also, the corporation was “re-engineered” during the field-work. While this did not affect Wideplant significantly (they simply offered early retirement to some supervisors), several thousand middle managers in the U.S. corporation lost their jobs and a number of corporate functions were ‘outsourced’.

Wideplant: change from 1980 to the time of the study

The history of work organization at Wideplant is dramatically different. As noted above, the precipitating event was a strike in the early 1970s which shook up site management. By 1979, relations had thawed, but there were still 13 layers of management on the site. Eight of these were eliminated in the early 1980’s.

At that time, the site obtained capital to build a new process area to manufacture a chemical which was rising in popularity in a local processing industry. Given a new process area and the emphasis on “Organizational Effectiveness”, management decided to experiment with a radically different form of work organization. The business manager for the new venture
was asked to design the new organization. He went on a tour of facilities within the corporation and outside and settled on a design modelled on a Proctor & Gamble plant.

The design was very similar to that implemented in Wideplant with three important exceptions. First, the plant was staffed with volunteers from all over the site, making it a quasi-greenfield site. Second, they had five crews, with one entire crew rotating to days every six months. Third, they did all the customer support work through roles known as 'customer championing'.

The operation was a tremendous success. There are three indicators of this. First, at the time of the study, the plant was significantly more cost competitive than the corporation's flagship facility, despite being smaller. Second, at the time of the study, the principal industry which the plant supported was deep in recession, so the national industry was tasked at about 30% of capacity. The Widesite plant had sold 110% of its product. Finally, despite the excess capacity in the country, the company was so confident that it built a brand new plant which opened in 1993.

As well as being a low-cost producer, the plant was able to offer extremely high quality service to customers. While a number of stories were used to exemplify this, the one used most often involved a customer who called at 2:00 a.m. on a Saturday, from 2000 miles away, to say that he had just made a terrible error and polluted all of his stored chemical. He would have to close down his plant in a couple of hours. The process controller he spoke to immediately diverted a truck to that customer's facility. He called back within an hour to say the truck would be there by the end of the weekend. Under the old system, the customer would have been told to call back on Monday morning. He then would have been directed to the sales office at corporate headquarters. The replacement chemical would have been dispatched on Monday evening at the earliest, and three days of production would have been lost. In addition to reducing the financial loss, this solution enabled the customer to present a ‘solved’ problem to his supervisor on Monday.

Shortly after the new process area started up, the site obtained capital for another new business. It was much smaller, and also started up with the new work system. However, this was not so successful. After a couple of years, safety performance started to lag, as did production capability. In part, this was attributed to a rapid expansion in the plant. It went to a conventional shift operation with a facilitator rotating with the crews and then returned to unsupervised operations with the rest of the site.

In 1986, Wideplant lost exactly half its market. Traditionally, it made two products. One was 'compound'. The other was an intermediate for another product. In the early 1980's, the corporation developed a cheaper and safer way of making the other product, so the demand disappeared. Suddenly, the plant had to operate two thirds of the process, but with only half the income. The business unit shed staff rapidly, going from 400 employees to 250 in two years. This attrition was managed through retirements, moving employees to jobs normally done by contractors, and moving people to other areas on the site. No one was laid off. However, Wideplant was still a very high-cost producer.

In 1988, the CEO of the conglomerate visited the site and received a presentation from the controllers in the new self-managed area. This was the first time, in his capacity as CEO, that a process worker had made this type of presentation to him. He was extremely impressed by the presenters' understanding of the business and the customers, as well as the production technology. Two weeks later, the site was authorized to double its 'compound' capacity by reproducing the back part of its production process. While a lot of other people had worked to justify the expansion, the visit and presentation were clearly instrumental in its approval. The crisis was over.
In the late 1980's, the senior management of the site, including the recently arrived current site manager, decided that the whole site would move to the self-managed model. People were trained in various jobs, foremen who did not buy into the new system were either asked to take up tools again or were asked to retire, and implementation began. Various elements of the prototype work organization were put in place over a couple of years, with the three exceptions described above (four crews instead of five, no or very limited customer championing, non-voluntary participants). By the time of the study, about half of the controllers had had their first rotation to days, and the secondary skills training involved only mechanical work.
14. What happens when organizations change

Dimensions of change

I observed three dimensions to the changes at Transitech, which varied in the extent to which they dominated the changes people were trying to put in place. First, changes necessitated altered technical tasks which people had to perform. That is, to complete the change successfully, people had to exercise a new set of skills and knowledge. These were provided by training and experience. We saw in chapter 8 that better training seemed to explain part of Wideplant's higher performance. However, I won't discuss predominantly skill-based organizational changes here.

Second, changes entailed alterations in the way people experienced their work. In particular, changed roles led to changes in the tasks people performed, and the way their work roles interacted with their roles in the outside world. This meant that people were asked to do things that they didn't do before, or that their work life and private life wouldn't be meshing together in the same way. They didn't always like this. This (along with other aspects of the change) implies that change has a political dimension. For example, we will see later that one of the big bones of contention was the interaction of the Wideplant rotation system with peoples' outside lives.

Finally, the changes altered the way people interacted. Sometimes these changes were minor, such as learning how to deal with a new boss or customer who was just like the old one. Sometimes, however, the changes were major, such as the move to self-managed teams. In this case, people had to learn what the change meant. This suggests that change has a cognitive dimension.

The rest of the dissertation is concerned with major changes in the way people interact and experience their work.\(^1\) That is, it is about changes which have significant political and/or cognitive components.\(^2\) Because of problems such as attribution errors and formal rationality, discussed in chapters 10 and 11, these two dimensions are not distinct. People can experience the cognitive aspects of a change as being political. Later in the chapter we will discuss a conflict between a Wideplant controller and a production coordinator. To a large measure, the conflict arose because the controller grossly misperceived the production

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1 As I noted, all changes require alterations in both skills and interactions. In addition, major changes in interactions may require people to develop new interpersonal skills (Argyris 1985). However, I won't deal with that here either.

2 Organizations change constantly. People come and go, get promoted, demoted, or fired. Task teams are formed and disbanded; production technology is added and subtracted; product mixes alter; suppliers are found and lost, as are valued customers; new markets are entered; new strategies are invoked; organizations are redesigned.
coordinator's power to decide whether the controllers should rotate to days. Furthermore, it is about designed change, change which is initiated deliberately. Since this was the case at the plants, we will assume that the change is being orchestrated by senior management.

What needs to happen during purely political change is theoretically unproblematic. Briefly, given a current organization, and a set of power relations and individual strategies, people put a new organization in place. The new organization will entail a new set of power relations. Beyond that, it won't be discussed here. Instead, I will focus on what is needed for cognitive change.

<table>
<thead>
<tr>
<th>Political change</th>
<th>Changed work roles achieved through strategic use of power</th>
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<tr>
<td>Cognitive change</td>
<td>Changed work roles achieved through changed understanding of the work process</td>
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Table 14.1 Two broad types of change

The cognitive change problem

If we make one (very plausible) assumption, we can reduce the cognitive change problem to one central conflict. Let us assume that people's behavior is underlain by a set of assumptions and beliefs about the world. If they are asked to do something that is consistent with their assumptions and beliefs, they will not find the request problematic; they will consider it "sensible". If, however, the request is inconsistent, they will resist it. So, for example, it doesn't matter whether people go to customer's sites because it makes them feel important, because they like flying, because they think management has a right to ask anything of them, or because they like change in their work. The important thing is that they must think it is legitimate for the company to ask them to fly to customers' sites.

So, when we talk about cognitive change, we have to talk about two sets of assumptions: the person's set and management's set. The person's set is the one he or she is carrying around at a given time. Management's set is the one on which it bases the requests it makes of its members. Most of the assumptions in the person's and management's set are compatible. That is, virtually all of a person's beliefs and assumptions about the world are either congruent with or irrelevant to those required to work effectively in the organization, or to come to terms with the change. We can now define a minor change (for a person) as any change that does not require major changes in their assumptions. For major change, the assumptions are different, and those differences have to be reconciled. Furthermore, some assumptions are systematically different. They have to change for a large group of people. Those are the assumptions which were required under the old system, but are antithetical to the new one. The central conflict then is the incongruity between the set of assumptions implied by the change management

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3 Notwithstanding, it is important to note that purely political conflicts (i.e. those which have no basis in cognitive differences) can and do exist. We can see this by conducting a thought experiment where we imagine two people with identical world views, preferences, and values, but different roles and power. It is easy to imagine conflicts emerging if one changes the demands he or she makes on the other.
wants to put in place and the set of assumptions people in the organization possess.

The existence of organization-level knowledge

Before continuing with the theoretical discussion, I will illustrate the idea of organizational knowledge -- a group of people holding a schema in common. Such a schema can be held by the group for one of two reasons. Either, people have been told to believe it, and they do, as an exercise in pure formal rationality. Alternatively, they have been taught a set of organizational assumptions, and the "fact" is compatible with those assumptions. The following proposition is believed virtually without question by people within the professional ranks at Transitech. It is illustrative because their belief is based in faulty logic. Therefore, we can see clearly the difference between an organizationally constructed fact and a "real" fact (as measured by science).

Transitech's managers and professionals believe almost consensually that the number of serious accidents and deaths which occur can be reduced by reducing the number of minor injuries which occur. Frequently at safety meetings, at both sites, managers would make this claim. The belief has its origins in a study performed by the U.S. National Safety Council, which found a consistent correlation between the number of minor injuries within U.S. industrial facilities and the number of deaths. Transitech's extension of this was that you can reduce the number of deaths by reducing the number of minor injuries and minor near-miss incidents. The pyramid which showed this correlational relationship was held up regularly at safety meetings, often alongside the Transitech numbers of incidents and injuries.

There were, however, two problems with the logical extension. First, just because incidents and deaths are correlated, it doesn't mean that they are causally related. It is very hard to see how reducing the number of times people cut themselves with pen knives will lead to a reduction in the number of electrocutions. If there is a relationship, it is through a large number of intervening variables. That is, minor injuries and deaths are loosely coupled. So, for example, the two outcomes could be coupled through 'attention'. If people pay attention, they won't cut themselves. If people pay attention they won't electrocute themselves. Therefore, reducing minor injuries by helping people to pay attention may well reduce the number of electrocutions. However, there are a number of ways of reducing the number of minor injuries that won't affect the death rate. For example, minor injuries and deaths are probably not coupled through the equipment used. If the organization avoided minor injuries by issuing special tools to replace pen knives, the death rate by electrocution is likely to stay the same or rise.

The second problem is that the ratio of incidents to deaths and serious injuries at Transitech is (statistically) significantly different to that from the National Safety Council sample. In particular, Transitech has many more deaths per incident than the other companies

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*In fact, one way of reducing the number of electrocutions might be to try to maximize the number of pen knife injuries! If management gave the mechanics the worst tools imaginable, they would have to learn to be very careful to avoid cutting themselves. This attitude of being careful would pervade the site and would lead the electricians to be very careful too. This would reduce the number of electrocutions. However, because the mechanics now have such lousy tools, they would cut themselves more often.
in the sample. For example, Highsite has five times the number of serious injuries per incident (and a much lower incident rate). This suggests three hypotheses. Either, 1) Transitech is drawn from a different population than other companies, or 2) At the margin, Transitech’s deaths have a different causal relationship to incidents (i.e. reducing incidents reduces the number of deaths up to a point, but Transitech is beyond that point), or 3) recording conventions are different at Transitech (e.g. because minor injuries are not reported). We can reject the third hypothesis, because it is hard to imagine a factor of five difference coming from under-reporting. That leaves the first two hypotheses. Both suggest that management is over-confident in its assertion that minor and serious accidents are correlated, and overly zealous in its attempts to reduce the number of serious accidents by reducing the number of minor ones. Therefore, we can say that it is principally a cultural belief among Transitech managers that further serious accidents can be reduced by further reducing the number of minor accidents.  

In the next section, I construct a theoretical model which can be used to explain the existence of a schema such as the one above.

Coupling of organizational action

In chapter 7 we discussed the coupling relationships between pieces of technology and between people and technology. I argued in chapter 3 that the plant could be understood in terms of four systems: the production system, the steam system, the control system, and the safety system. I said that there was relatively tight coupling within these systems, and looser coupling between them (with the exception of some links between the safety system and the production system). I defined tight coupling in terms of the speed and certainty with which a perturbation at one end of the system would travel to the other end. I then described the way that work is coupled to the technology, and argued that routine work is tightly coupled to the technology while exception management is only loosely coupled to it. Learning from exceptions, I argued, is virtually decoupled from it. In this section I will extend that argument further to talk about the coupling relationships between peoples’ actions and minds. Whereas the technology provided the anchor in the first two cases, the anchor in this case is provided by the history of relationships between people.

Imagine you are a site manager. As you walk across the site one day, you see a mechanic standing onto a ladder, about to step into a distillation column. You look up and notice he is wearing the right harness, the right clothing, the right breathing apparatus, and the right gloves. Furthermore, the stand-by operator at his side is wearing the right gear, holding the right monitoring equipment, and talking on the radio to the control room saying they are starting the entry. Sticking out of his pocket you see a pink piece of paper -- a confined space

5 I am not making the claim that culture is based entirely in illogical thinking. Rather, it is much easier to show the existence of an element of a culture if it deviates from a norm the reader subscribes to. Furthermore, I am not saying that the managers are misguided in their belief that serious injuries can be reduced by reducing the number of small ones. I am saying that the logical and statistical evidence suggest that it is not a belief that one can justify holding strongly or uniquely.

6 The example is completely fictitious.
entry permit. You walk up to the column and see that every flange has had a blank put in it, and that all the valves have been locked shut and tagged. The job is neat and clean; the sun is shining; you are happy. You smile, congratulate yourself for being such a good site manager, and walk off to your meeting.

We run into each other on the footpath and I ask you why you are smiling so broadly. You point to the operator and mechanic and tell me with pride that you led a safety meeting last month on procedural compliance, and the results have clearly been phenomenal. I ask you if you are sure that the operators' performance is the result of the meeting. There could be other reasons. Is it really the wisdom of the safety meeting, or is it the training they received beforehand, their supervisor who loves disciplining people, their plant leader, their business manager, their experience having seen other people hurt, a fear of getting hurt, or the training their parents gave them to be safe? And, if it was their parents' training, are you capturing it through luck or your brilliant trainee selection process? You think about this question for a while and give me an answer. At lunch time, in the cafeteria, I discuss the same issue with the operator and the mechanic.

The above vignette suggests a number of things about the organization. First, people believe that actions in the organization lead to outcomes within the organization. That is, people think management matters. The way some people act determines, at least in part, the way some other people will react. We saw this proposition originally as figure 1.5.

![Figure 14.1](image)

Figure 14.1 A representation of the over-arching idea that organizational outcomes are achieved by the act of "management" applied to the organization.

Second, different actions have different causal significance. That is, some actions are very tightly coupled to others, some are loose, and some are decoupled. For instance, since you were standing at the bottom of the column and you had said at the safety meeting that you would sack anyone you saw violating the rules, you think the chances are very high that the operator and the mechanic were in full compliance with the rules because they saw you coming. Although this part doesn't make you happy, you believe your presence and their compliance were tightly coupled. On the other hand, you believe the formal training you gave them probably had limited impact, since you gave the mandated package, just like all the other plants in the county. You point out to me that your safety record is better than that of anyone else in the county, so the standard training couldn't be the explanation. However, you know that some people really respond to those training videos. That is, the training and the behavior are loosely coupled. Finally, you think the behavior has nothing to do with the new health benefits package. That is, you believe those two are decoupled.

Third, different people see the causal process differently. On some issues there will be consensus. The operator and the mechanic told me they were scared by your threat and did, in fact, increase their level of compliance after the safety meeting. However, in other areas, there was disagreement. For instance, the mechanic had read somewhere that distraction leads to accidents and he remembered that last time the corporation announced a layoff there were fifty injuries the following week. He decided to be extra careful after any bad news in the future.
Finally, different people see different aspects of things as important. While you think the threat you made in the safety meeting was the clincher, the operator and the mechanic claim they would have responded the same way irrespective of the threat. A comment by their supervisor just after the meeting, about protecting themselves to protect their children, really hit home, and so they decided to be more cautious. However, given that they saw you, they were extra careful. Similarly, while you thought the medical benefits program was unimportant because of the low disability payments, they thought it was important because of its impact on peoples’ concentration.

In other words: 1) People within the organization believe that organizational characteristics such as assumptions, principles, structures, and rules determine organizational outcomes. 2) While, in general, they agree on most of these relationships, they disagree on some. 3) That disagreement can take one of four forms: Either, i) they can disagree on what the organizational characteristics really are, or ii) they can disagree on the tightness of the coupling between a particular organizational characteristic and a particular organizational outcome, or iii) they can disagree on the way the organizational characteristics interact to produce the outcome, or iv) they can disagree on what the outcome really is. 4) The above four disagreements reduce to disagreements of two fundamental types. The first is a disagreement about what a thing is (i, iv). The second is a disagreement about the causal relationship between two or more things (ii, iii).

It is not a great conceptual leap to map these two fundamental types of understanding onto the building blocks of image schemas and proposition schemas, and four ways of defining the relationships within and between them: metaphor, metonymy, routinization, and formalization. For example, the differences in the understanding of the workers up the column and the site manager can be understood in terms of differences in image schemas (how they understood objects) and propositions schemas (how they understood causation).

How people understand the organization

If we define organizational knowledge is as the set of image and proposition schemas people hold in common, it follows that people can vary in their participation in the organizational knowledge system in three ways. First, they can deviate in the degree of coupling they believe is implied by a given proposition schema. That follows directly from the argument above, and will not be discussed further. Second, they can vary in the schemas they share. Third, they can vary in the depth to which they share a given schema.

If we consider the schemas people share, we realize that most schemas will be held

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7 By this, I mean knowledge which is emergent at the organizational level, not the sum total of knowledge within the organization. Organizational culture might be a better term, but it is usually defined to include artifacts and values as well (Schein 1985).

8 Parenthetically, this suggests that we can measure an organization’s organization-level knowledge on three dimensions. One is the content of the shared schemas. The second is the depth of the sharing, and the third is the cultural strength, which would be determined by assessing the number of schemas held in common throughout the organization, the proportion of people who hold them, and the strength with which they hold them.
almost universally within the organization. Those are the ones that are very closely tied to physical things, or are held within the broader community in which the organization resides. For example, everyone on either site would have approximately the same schemas for what a pump is, or how it works. Similarly, everyone on a particular site would have very similar schemas about the importance of integrity in a person's behavior and the way that is constituted. However, we would not be surprised if the schemas for integrity held at the two sites are quite different since the sites are in very different communities.

However, people will hold other schemas differentially. While some of the differences will be purely individual, others will vary on the basis of group memberships. Group schemas can vary for two reasons. The first is that groups have different histories and knowledge, and therefore different perspectives on organizational issues. Some obvious sources of variation are differences in 1) expertise: We expect mechanics, who are experts in pump maintenance, to understand pumps differently to operators, who are not; 2) experiences of organizational life across functions: One of the main points of the Wideplant secondary skills and day point rotations was to give the controllers different perspectives on the production process, rather than to give them new skills; and 3) experiences of organizational life across time -- older operators, for instance, were socialized into a very different work environment than the younger ones. Not surprisingly, that different socialization translates into a different contemporary understanding.

The second reason why different groups can have different schemas is because they have different interests. Not surprisingly, it is often easier for people in a given group to see causation for bad events in terms of the agency of others while they see themselves as responsible for positive outcomes. If people see this as "truth" it is called a fundamental attribution error, and can arise for either psychological (Nisbett and Ross 1980) or political reasons. For example, operators might well see accidents as being caused by engineers and management, engineers might well see them as being caused by operators and management, and management might well see them as being caused by engineers and operators.

In addition to varying in terms of which schemas they hold, people can also vary in the depth to which they hold a given schema. Following from Bourdieu (1977), I argue that schemas vary between two extremes. At one extreme are propositions and images which people assume unthinkingly to be true. For example, we all assume that time travels forward, that the night sky is black (even though astronomers tell us the sky is white and we have lousy eyes), and that apples fall downward (though Newton proposed that the earth also falls upward).

At the other extreme, different groups can make different claims about images or propositions while they are fully conscious that there are other ways of constructing the reality and that they could hold alternative views just as easily. For example, one of the big items of contention at Highplant was the extent to which someone's history of service in the company insured them against punishment by management. Management -- particularly the site manager -- was pushing a strong line that careless and irresponsible behavior was punishable, irrespective of the perpetrator. The production employees believed that people had some sort of a 'bank account' with the corporation and that the punishment for a given crime should depend, at least in part, on the person's history of service. At Wideplant a major dispute arose over management's right to dictate people's work schedules and tasks. Management believed it had the right to ask people who had worked shift as process operators all their lives to work days doing office work. The controllers believed they had a right to more control over the sorts of hours they worked and the type of work they did.

In summary, in this section we have seen that we can build a map of the organization based on two building blocks: proposition schemas and image schemas. If two people hold different maps, they are likely to differ on one or more of four dimensions: 1) which image
schemas they hold, 2) which proposition schemas they hold, 3) the tightness of coupling between images implied by a given proposition schema, or 4) the depth of their belief in a given proposition schema.

How the organization is constructed cognitively

Given this lengthy introduction, we are now in a position to lay out a model of the organization as it was probably constructed in the heads of the people in the plants. I postulate that the organization exists in peoples’ minds as a nested set of proposition and image schemas. I will start at the most macro level, and move down. I will refer to the overall model, in all its complexity, as peoples’ mental map of the organization.

At the highest level, people had proposition schema: "that ‘management’ of the organization led to ‘organizational outcomes’” (figure 14.1 above). This belief was held very deeply within the organization. From this, it follows that people have two sets of lower-level image schemas. The first set is a model of the organization, including its institutional and physical environment, the people within it, current power relations, its physical infrastructure, and so forth. The second set is the organization’s outcomes. These outcomes include production, promotions, income, future power relations, happiness, safety, pollution, and so forth. The outcome schemas are divided into two sets. The first set is the production outcomes. The second set is the interpersonal outcomes.

Each of these three sets of image schemas is held together by a set of proposition schemas. There are propositions linking the organizational inputs to each other, propositions linking the production outcomes to each other, and propositions linking the interpersonal outcomes to each other. The three sets of image schemas are also linked collectively by three sets of proposition schemas. That is, there are propositions linking the organization to production outcomes, propositions linking the organization to interpersonal outcomes, and propositions linking production outcomes to interpersonal outcomes. (figure 14.2).

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9 An important methodological point which needs to be reiterated is that I was unable to verify that people actually have this sort of model. I have constructed this model retrospectively to make sense of the data I collected. The model is, however, consistent with a large body of theory.

10 In the case of safety management, this proposition is held to the exclusion of all others, though not as deeply. It is official corporate policy that the causes of all foreseeable accidents in Transitech plants can be managed.

11 As an extension of the argument in chapter 1 (or this chapter for that matter), each of the schemas within each set is not a unitary concept. Rather, unless it is learned whole through socialization, it is, itself, an amalgam of basic categories, constructed around metonymic prototypes joined together by propositions based in metaphors. (see (Lakoff 1987)).
Each proposition schema may map a one:one, one:many, or many:one relationship between image schemas and may involve interactions between the image schemas. A one:one proposition is that "distractions cause lack of attention". The image schema 'distractions' has many parts including bad weather, accidents off site, threats to close down a business, and personal problems at home. A many:one proposition is that "an interactive combination of release of energy from uncontrolled sources, lack of personal attention, and a failure of organizational systems cause accidents".

It should be apparent that a given proposition schema has characteristics on the three dimensions described in the previous section. First, it can be held by a small group of people, or it can be held universally (or somewhere in between). Second, it can be held deeply, or it can be held lightly. That is, it can be assumed to be a statement of truth or it can be assumed to be a statement of political position (or something in between). Third, it can be held strongly, or it can be held weakly. If it is held strongly, then we say that the image schemas it joins are tightly coupled. If it is held weakly, we say they are weakly coupled. If no proposition schema joins two image schemas, we say they are decoupled. Similarly, the image schemas are also negotiable to an extent. However, since there seemed to be a consensus about the reality within the organization, I won't discuss it further here.

For example, the statement that "it is the production supervisor or plant leader's prerogative to demand things which are consistent with 'good practice'" corresponds to a set of proposition schemas that are universally, deeply, and strongly held in the organizations. When the Wideplant area 'A' supervisor commented at a morning meeting that there was lot of ice on the ground in the production building and he thought it was unsafe, it was not questioned that people would clean it up that day. Conversely, the statement that "accidents are caused
fundamentally by people not obeying the rules" is narrowly held (by management), lightly
held (as evidenced by the large amount of political rhetoric and broad extent of punishments
meted out when it is enacted) and tightly coupled (management sees a strong linkage).

We can see the role of categorization when we consider the meta-level constructs. It
would be possible to represent the causal map above without the heavy black boxes. Then, we
would just have a network of causal relationships. However, people don't think in terms of
such a network. Rather, they break their worlds up into discrete subsets. Similarly, we could
arrange those subsets differently. Presumably, a number of historical processes (and hence the
strength of the coupling arrows) determines which boxes exist and which elements go in which
box. As note earlier, if we wanted to trace those historical processes, we would examine the
role of metaphor and metonymy (Mylonadis 1993), but also the role of routinization and formal
rationality.

Cognitive change at the organizational level occurs when there is a move among all the
people in the organization -- or the relevant subset -- toward consensus in the proposition or
image schemas held, or beliefs about the relationships between them, along the dimensions
described above (strongly:weakly, deeply:lightly).

Traditional models of change

Given these two dimensions of change, the political and the cognitive, it is not
surprising that there are two dominant models of the change process in the literature, which I
will call the social cognition model and the political model. They correspond directly to the
strategies of changing the individual's assumptions above (a social cognition approach) versus
the idea of negotiating the change so be mutually satisfactory, i.e. a political model. Here are
stylized versions of these models.

The social cognition approach

With this approach, change begins when the organization stumbles on the realization
that something is amiss. A crisis initiates these changes by disconfirming the adequacy of
present shared understandings of the situation (Bartunek 1984; Fiol and Lyles 1985; Tushman
and Romanelli 1985; Schein 1992). This unfreezing tends to traumatize the individuals
concerned (Schein 1985; Bartunek 1988). However, given appropriate psychological security
(Schein 1992; cf. Staw, Sandelands et al. 1981), unfreezing also enables people to become open to
new interpretations and understandings and begin to search actively for solutions to the problem
they face. At this stage, different parts of the organization generate large amounts of
discrepant information. Effective solutions require that the discrepancies be maintained until
they can be resynthesized coherently (Bartunek 1988). In the next stage, participants generate

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12 This model neglects the role of enactment. As we saw in chapter 7 there are many
exceptions in a plant, and many of these are large enough to be labeled as crises. However,
not all are. Rather, as we will see in chapter 17, it is more accurate to say that the event
creates and opportunity for people to enact a crisis if someone in the organization, with
appropriate power, wants to.
alternative new frames from the disparate views and finally, the organization moves toward (Bartunek 1988) a shared reconceptualization of the problem.

The political approach

Under the political model, people who have been asked to change identify and articulate their assumptions to management. Through an extended dialogue and rounds of mutual threatening, they either change the problem or their understanding of the problem so they see the same issues (though possibly differently). Resolution then comes through either coercion and capitulation, or through compromise (Zald and Berger 1978). For example, one Wideplant controller had a business which required him to be outside in the Summer. If he had to work a day rotation in the summer, at the plant, he wouldn’t be able to run the business. He fought for about a year with the area ‘A’ production coordinator about whether the company had the right to change his work schedule in a way that sabotaged his outside business. However, he constructed an argument by holding a threat over the production coordinator’s head. Because of his seniority, the controller could accrue enough vacation time in a year to take leave for any part of his day rotations that were in the Summer. If he did, it would disrupt the organization completely. The conflict was resolved a couple of days before the end of the field work, but it was unclear whether the resolution was going to stick.

Problems with the traditional approaches

There are at least three problems with these traditional approaches to adaptive change, which make them inappropriate for discussion of the changes in the plants here. The first, and major problem, is that they are generally presented as mutually exclusive. That is, cognitive accounts of organizational change are remarkably devoid of politics, and vice versa. However, we saw in chapters 10 and 11 that the intersection of politics and cognition was vital for our understanding of the differences between the plants. The problem of attribution error arose when we brought social cognition into a political environment, while the idea of formal rationality was a solution to the problem of not being allowed to think because of the politics in the workplace. Therefore, we need a model that accounts for politics and cognition simultaneously.

Second, the social cognition models of change always treat the assumptions that have to change as being very deep and very fundamental to the people. That is, it is assumed that until the assumptions are surfaced, they are essentially inarticulable. This is a poor assumption for two reasons. First, corporate cultures are, to a large measure, learned. That is, people are socialized to them after joining the corporation (Van Maanen and Schein 1979). I think it is reasonable to assume that they still have some memory of what they used to believe, even if they don’t believe it any more. As such, they know there are other possibilities. Unlike traditional ethnography, where the study of a culture is a study of the culture, a corporate culture is only a veneer on the top of a broader social context. Second, we are well beyond the stage when people were unaware that their corporations had a culture. A casual conversation with most employees in Transitec, certainly most at a managerial level, would rapidly reveal a comparison of their culture, as they understood it, to that of nearby firms or competitors. This second point suggests that we need a model of the organization and change which allows for the possibility of assumptions being held lightly.

Finally, these models treat the organization as a closed system. That is, they assume that all of the changing has to be created by people in the organization adapting (rather than
Toward an outline of a synthetic model for thinking about change

Given the critiques above, I needed a framework for thinking about the dynamics of the changes I observed. Although this framework doesn’t have much content, it does provide a basis for looking at the change process. Principally, I realized that you (the analyst) have to separate the parts of the change that are obvious to everyone from the parts that are subtler. I call these obvious elements the "macro" design, and the subtler aspects the "micro" design.

**Macro design**

The macro design is the broad outline of the implementation, while the micro design involves the details. Macro design is not problematic. With an hour in an airport bookstore, anyone can get a pretty good idea of 1) what is wrong with traditional organizations, and 2) what to do to fix them. For someone particularly smart and willing to take an extra fifteen minutes, it might even be possible to work out whether what is wrong with traditional organizations is also what is wrong with their own, and whether the solution being advocated in the books would make any difference. If they have trouble making that leap, they could allow some high-powered consultant to carve another notch in his shingle. The consultant will prescribe a solution and, with luck, the solution will be appropriate for the organization.

The point is that there is nothing mystical about the sorts of changes required in contemporary organizations. The books that line the airport walls talk about statistical quality control and quality circles (or whatever the current fad happens to be) as if they are difficult to understand. They are not. Similarly, when you get to the bottom of the changes management was trying to make at Wideplant, they can be summarized in one sentence: Management wanted everyone on the site to behave like an intelligent, responsible, respectful adult who filled his or her work time productively.

Therefore, to analyze change at the macro level of "best practices" is a waste of time. Cognitively, there is nothing mysterious about them. They are easily understood. Politically, people are capable of seeing the barriers quickly, and either negotiating their way around them, or giving up.

**Micro design**

However, given that these very simple changes have been tremendously difficult to implement in anything but greenfield sites, including the very slow implementation at Wideplant, it would appear that the problems are in the micro design and implementation. I assert that the central design problem is that the fine details of an organizational change depend on the prior context in which they are embedded. However, that context is extremely complex, and operates in large measure at the level of individuals’ psychological assumptions.
and values (Schein 1985) and preferences. While people can see the conflicts at the political level (differences in preferences), people inside the system are barely aware of the relevant psychological dimensions, and have trouble separating them from politics. They will only become aware of them once they are challenged (Bourdieu 1977).13

The highly contextual (and unexpected) nature of the barriers is illustrated very clearly by the dependency of the Wideplant organizational design on the structure of the product market. Only at the time of the study, four years after initial implementation of the new organizational design, were people starting to realize that one of the key differences between Wideplant and the prototype on which it was based was that the prototype’s controllers spent a lot of time interacting with customers. People really enjoyed this part of the work, so it provided a tremendous amount of intrinsic motivation to 1) develop the skills which both management and workers thought would be useful either in the plant or at customers’ sites, and 2) tolerate the parts of the organizational design which they thought were dumb but which management thought were important. Wideplant could not provide intrinsic motivation or a need for the skills through customer contact, so there was a lot of resistance from the controllers in the other domains.

Stages of adaptive change

As with any action (see chapter 1) a change has three elements, sense-making, design (problem solving), and implementation. These do not have to occur sequentially. Implementation can precede design and sense-making, as in the garbage can model (Cohen, March et al. 1972) or a behavioral model (if you can get people to act a certain way, they will start to believe it is the right way), or design can precede implementation, as in most other change models (e.g. Tichy 1983). I argue that in effective planned change, design must both precede and follow implementation.

If design does not precede initial implementation, as in the garbage-can model, the organization will take a random walk down the path of least resistance. Changes will tend to reflect existing power relations and communications structures. The result will be that, on average, the organization will end up entrenched in some minor variant of its initial state. Therefore, macro design must precede implementation. If, on the other hand, people try to design everything in advance, they will discover that they cannot know the details of the barriers to implementation a priori. The problem is simply too complex and too heavily embedded in a context of which people are barely aware, if at all. They cannot work it all out in advance.

If micro design and implementation co-evolve, it means that the details and conflicts between assumptions will emerge as the organization plays out its attempted changes. Once the conflicts emerge, however, some sort of mutual adjustment must occur. That is, the participants’ assumptions and/or the organization’s demands must shift to reach an accommodation which is acceptable to both groups. That shifting is not easy.

13 There will be obvious conflicts (rather than unenunciated ones) also. However, they will be apparent, and therefore one of three things will happen. Either, they will be resolved before implementation is attempted, or change won’t be attempted, or the change will be attempted in the face of an obstruction, as happens with union busting.
In the next four chapters, we look at the process by which that micro design occurred. First, we examine the strategies management used to put in place. Then, we will examine the barriers they came up against, and why. Finally, we will examine change which resulted from the strategy which I call "strategic sense-making".
15. Strategies for change

The history of change theory, starting with Darwin and Lamarck, is characterized by the notion that change can occur by one of two ways, by selection and adaptation. The broad idea with a selection approach is that you change people's cognitive assumptions or political aspirations by replacing the people. The broad idea with an adaptation approach is that you change people's cognitive assumptions or political aspirations by working with the people that you already have. These two perspectives on change have carried through into the literature on organizations at both the population level (Hannan and Freeman 1984), and the level of the individual organization (Nelson and Winter 1982; Schein 1985). Therefore, as a first cut, I will divide the strategies management used into three groups. First, I will examine direct attempts to change the people. Then, even though Transitech generally offers life-time employment, I will show management's success in replacing people. Finally, I will demonstrate the way that by using these two strategies in tandem, a type of flexibility emerged which created a set of strategies at the intersection to facilitate adaptation.

Change by adaptation

I observed managers using three broad strategies to change the organizations in which they were working.¹ Two of them will be discussed at length in this chapter, while the third will be discussed in the final two chapters of the dissertation. The first strategy was one of "teaching". That is, through their words or actions, people would use opportunities to either explain or demonstrate the new organization at work. The second approach was one of proactive restructuring. That is, management would use its power to change the rules by which the organization was constituted. These rule changes were expected to lead to cognitive and behavioral changes. The third approach is one of opportunistic interpretation. That is, participants would negotiate the meaning of events, and through their negotiation would develop new organizationally sanctioned understandings of the world they inhabited.

Change by teaching

This is probably the most obvious way in which change can occur. Given a situation, people will teach others the correct way to understand it. One way that this can occur is through the constant telling and retelling of organizational stories, with different parties recreating the history of the organization in a different light to reflect their interests and beliefs (Boje 1991). That is, through the organization's ongoing process, people are constantly recreating it (Giddens 1984), and through that recreation they try to influence its form. This form of change is different from the ones that follow in that that the causal links don't change in the rewriting of the story. Rather, people generally try to change the story by changing the

¹ There are possibly many other strategies available. I only observed these three in the plants.
weight on the relevant elements. We saw an interesting example of this when the Highsite plant manager attended the supervisors’ safety training and spent the lunch time telling stories about incident investigations he had sat on. It does not appear that he was trying to be strategic, but rather, by telling the stories, was unintentionally reinforcing an accretive view of the world in which it is acceptable for people to implement changes they know to be not based in fact.

Second, people would try to teach each other the new map. That is, they can say that what someone believed to be true in the past is no longer the case. For example, the area B-C production coordinator at Wideplant had a piece of paper called “the 12 new rules” which explained the new ways in which people were expected to behave (be proactive, empower yourself, etc.). He would hand out copies liberally. More formally, Wideplant had extensive training in place using programs from its two gurus. Everyone on the site received a three-day workshop based on Covey’s *The seven habits of highly effective people: Restoring the character ethic*. (1989). Similarly, the coordinators and managers would go off for regular seminars led by Charles Kron and his disciples. A third example we have seen is the lecture given by the Widensite manager at the supervisor safety training. In his talk, the site manager laid out very clearly a way of thinking about the relationship between work organization and accidents.

However, such a lecture also served another purpose. By getting up and giving a lecture, rather than simply having a meal with the supervisors, the site manager was also demonstrating his expectations of a manager’s role. Namely, he didn’t think it was sufficient for him to just demonstrate that he thought safety training was important (the symbolic reason for being at the dinner). Rather, he saw his role as site manager as being principally one of a learner and a teacher. By extension, he also saw that role for the supervisors who worked for him. By giving this lecture, he demonstrated that belief.

Probably the most interesting example of teaching the organization by demonstration comes from an incident investigation at Wideplant. The business manager was leading the investigation, and the main person involved in the incident was an extremely shy trainee process controller. The business manager made sure that the process controller’s story was told at the investigation, not anyone else’s. This required him to patiently encourage the controller. It would have been much easier for all concerned to simply get the story from the articulate controller who was also involved in the incident. In fact, the manager spent a good deal of time making him be quiet. However, he used the opportunity to try to build the confidence of the trainee.

As we will see in chapter 17, teaching was the dominant change strategy at Highplant. An interesting formal effort was a program which taught people to “stop” work as soon as they perceived anything was astray. In addition, management threatened people who were found to be violating procedures as a variant on operant conditioning. Again, this will be discussed further in chapter 17.

*Change by pro-active restructuring*

The second strategy I saw in place was one of actively changing the underlying rules of the organization and, on the basis of those new rules, changing peoples’ behavior. In theory, when their behavior changes, their beliefs will too, either as an exercise in dissonance reduction, or because the new rules have given them new insights into the situation and hence a new way to understand it. There are two types of change which change agents can specify. Either, they can specify a ‘rule’ or they can specify a ‘principle’. A rule might be something
like a 'best practice' or a structural arrangement. A principle might be something like, 'We want people to be mindful of their actions the whole time'. The key difference is that a rule specifies the way people should behave, while the principle specifies a heuristic which will generate a rule which determines how people will behave. In the next section, I will discuss what is implied by implementing a rule. We will see that it won't take us where we want to go unless it operates at one level below that of actual behavior (e.g. structural rules such as procedures for learning processes, or job rotations). Then I will discuss implementing principles.

*Implementing a rule*

A rule is a specification of the way people should behave. An important example of a rule is a "best practice" which many people propose as the way that companies can achieve competitiveness. A person who is behaving in a particular way is either complying or not complying with the rule. Therefore, compliance with a rule is pretty unambiguous and pretty easy. However, rules which specify production behavior are also a pretty useless vehicle for organizational change. The new rule will either be consistent with the underlying assumptions of the organization, or it will be inconsistent. If it is consistent, then implementing the rule will not be problematic. It also won't represent a significant change.

If, on the other hand, the rule is inconsistent with the underlying principles, there are three options. The first option is to change the rule to suit the underlying principles. For example, during the early post-war period, Japanese businesses adopted Western business practices, but modified them to suit the Japanese context. If the organization pursues this approach, and doesn't alter any of its underlying principles in the process, we have change without change in the underlying beliefs. There has been change, but there has not been real change. If, on the other hand, the principle changes, we have a simultaneous change in the rule and the principles. This is a variant of the third option below.

The second option is often referred to as institutionalized change (Meyer and Rowan 1977). The organization implements a symbolic version of the rule and keeps it decoupled from its core organizational principles. The rule stays intact; the principle stays intact; nothing really changes. The clearest example at Transitech came from a discussion I had one lunch time with an engineer. I asked about a new corporate change initiative. She said, "Oh those, we just use the new words for six months and keep doing things the way we always did." This was probably worse than useless since it tended to litter the organizational landscape with the detritus of past change attempts. Transitech literally oozed jargon. Each time such an institutionalized change occurs, it undermines the legitimacy of every subsequent change attempt.

The third option is for a change in the rules to precipitate a change in the underlying principles. This is part of the idea behind 'business process reengineering' (Hammer and Champy 1993). By completely obliterating the organization and rebuilding it, Phoenix-like, those who are left behind have to reconstruct their behavioral principles within the constraints created by the new situation.

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2 This engineer was not the only one who had internalized this principle. Virtually everyone at Highsite and many people at Widesite were clearly using a similar approach. Many people had dictionaries of corporate jargon, which they would tell me about with pride and laughter.
This raises an important empirical question. Which characteristics of a given rule change and organizational context will lead to which response? That is, when will an organization change the rule to conform with its principles, when will the two remain decoupled, and when will it change the principles to satisfy the rule? This is not the place to review the whole literature. However, a couple of broad propositions are in order, in addition to those which follow directly from the discussion of principles, below. Principally, the impact of a given proposed rule change on the organization depends on the way it is interpreted and enacted. There are structural and process-based determinants of this process. Structurally, if the rule change is seen as either important, or not terribly different from the status quo, it is likely to be implemented intact and the underlying organizational principles will change to suit. So, for example, if the organization believes it has a performance crisis (Tushman and Romanelli 1985), or if the remains of the organization can’t support the old principles (Hammer and Champy 1993), or if the proponents of the change are seen as legitimate, change is likely to occur. If the change is seen as unimportant, it is more likely to be rejected, changed, or enacted symbolically.

Symbolic implementation is most likely in loosely coupled systems (Meyer and Rowan 1977). More precisely, symbolic implementation is more likely if the person who is advocating the rule doesn’t have the power or insight into the organization to see whether the principles are changing, but does have tools to see if the surface manifestations are changing. In terms of process, if people have a behavioral routine for enacting the rule, then the consequences of that routine are likely to be more important than the meaning of the rule in determining the final outcome. For example, if people ‘used the words and kept doing things like they always have’ last time a new rule was introduced, the chances are they will do so next time also, irrespective of the rule’s content.

We can see that changing behavioral rules and expecting the underlying principles which drive the organization to change as a result is a losing proposition. It is impossible for someone standing outside the system to create any meaningful change in behavior by specifying a rule, unless there is a crisis. Even then, there are no guarantees that the organization’s members will spring to the ‘right’ conclusion. Therefore, it would appear that the only route to gradual change is through the advancement of principles.

*When implementing a rule can lead to change*

There are two types of situations, however, when implementing a rule makes sense. Both were used at Wideplant. The first is to use a rule to change people’s behavior radically. Through that changed behavior, the change agent hopes to change their world view (i.e. conditioning). The obvious example here is the use of rotations to get people to do administrative work and secondary skills training. In both cases, the aim was not to give people skills in that particular task. Rather, the aim was to give them different understandings of the work process. As we saw above, it is not clear that it actually worked.

The second is to change the rules which people use to generate the behavioral rules. In particular, management at Widesite put a tremendous amount of effort into changing the procedures by which learning occurred, in two key domains: incident investigations (through a

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3 This is the major problem with ‘flavor of the month’ change programs. If they wanted, the plants could have spent half their time getting certified as meeting new corporate change criteria while not changing the way they operated at all.
process called "analysis for cause" (see chapter 17) and interpersonal communications (through a process called "triads" (chapter 9)). The assumption was that different learning procedures would lead people to learn different things and, as a result, generate different understandings of their situation.

The important thing to note is that both the rotations and the learning procedures, unlike usual behavioral rules, operated at an infrastructural level. They, much like the principles in the next section, were generative of the rules which governed production behavior. They did not specify production behavior directly. Furthermore, their execution was controlled by people who had already bought into the new work system.

*Implementing a principle*

The alternative that the change agent has, then, is to propose a new principle, or set of principles, which people will accept as sensible. To accept them as sensible, people may have to change some of their assumptions about the nature of organizational life. Once accepted, people can then use the principles to guide their actions. In particular, they will use them to design (Barnard 1938) or generate (Barley 1986) structures for organizational action, and rules for behavior within those structures. There are two broad approaches which can be used to introduce the new principle. One is the behavioral approach described in the section above, where management would ask the organization's members to exhibit behaviors which can be derived from the principle/s, with the hope that understanding would follow. The other is a cognitive approach. Management would try to get the organization to understand the new principle/s, and from that, people would learn how to generate the new behaviors. In practice, the two were used in combination. Managers introduced new structures and procedures and explained why they were doing so.

However, in addition to the main problem of developing congruent assumptions between the individual and the organization, there are three complications. First, for a number of reasons laid out in the next chapter, different people in the organization will start to believe in, and act upon, the changes at different times. Some will see the change as sensible immediately (as everyone does with green-field sites); others will see it more slowly; some will never see it. Second, as the organization attempts to move from one logic to another, there will be a conflict between the current system of production and control, which is premised on the old system of organization, and management's normative model. Both will have to operate simultaneously, and this tends to be very disorienting. Third, the management is always trying to implement conflicting objectives. Therefore, while managers can say what they want in general, the specifics of their wishes will be emergent. People will experience a logical conflict within the organization's design. They won't know what is expected of them. In the next chapter, I will lay out the nature of these conflicts in detail.

*Change by opportunistic interpretation*

Finally, there is a fourth method of adaptive change which we will encounter in detail in chapter 17. Sometimes an event occurs, such as an accident inside or outside the organization. Either because the causal map has been thrown into question in some way, or because it is simply mandated by procedure, the organization opens up its causal map for inspection. That is, it examines a particular organizational outcome and determines its causes. Temporarily, the propositions joining the various image schemas, and the image schemas themselves, are suspended and are available for renegotiation. The people in the organization then determine the causes by creating a new story for the organization: a story about how this event came to
happen. That story then becomes a new tale to be retold in the recreation of the organization in the future. Often, by creating the story, the organization will recreate and reinforce its prior understanding of itself. On other occasions, however, the map will be recreated completely. New propositions will be added, old propositions will be questioned, the tightness of coupling implied by proposition schemas will be changed, or image schemas will be recreated in a different form (generally very rare). That is, organizational learning will occur. Sometimes, everyone will agree on the new propositions. On other occasions, they will remain disputed for years.

The hook

The problem is that organizational learning experiences are a bit like courts of law. In a court, the judges decide two things. First, they decide a particular case, presumably on the merits of the arguments pertaining to that case, and only to that case. Second, however, that case becomes a precedent for future cases. The decision is a much more general statement about justice. Similarly, when organizations are determining causes of events, they are determining two things simultaneously. They are determining both what caused the particular event (the set of propositions joining the organizational image schemas to the production outcome image schemas) and they are determining what causes interpersonal interactions in the organization (the set of propositions joining the organizational image schemas and the interpersonal outcomes image schemas). Both of these is going on simultaneously, and most statements people can make can be seen as an attempt to exert influence over either causal system.

The dual nature of learning is illustrated very clearly by an event which occurred exactly 30 minutes into the formal data collection for the study. I was attending a meeting of the Transitech corporate energy group. The second presentation was by the engineer in charge of process efficiency improvements. He talked about "why energy conservation is like safety management". His argument was essentially that if we thought that energy management and safety management were analogous, we could use the Transitech safety programs as a guide to see which energy management programs the group should consider putting in place. The presentation was low-key, interesting, and relatively innovative. However, apparently from nowhere, the engineer was attacked viciously by the engineer in charge of a group which was trying to modernize the power houses in the businesses. The energy conservation engineer wasn't expecting the attack at all, and was clearly shaken by it.

Given that I had absolutely no credibility in the group at that point, it wasn't possible for me to ask the protagonists what happened. Even if I had had the credibility, I doubt they would have told me. However, the following is the most plausible explanation I could develop, and a number of people in Transitech who were at the meeting have agreed that it is likely. The energy conservation engineer was making a statement about the relationship between organizational image schemas and organizational production outcomes. In particular, he suggested that if they assumed that the causal relationships which lead to energy conservation outcomes are analogous to those which lead to safety outcomes, then it follows that they should at least consider replicating the organization's safety management structures to manage energy. The other engineer saw something different. He saw a statement about the relationship between organizational image schemas and organizational interpersonal outcomes. At the time, he appeared to be trying to use the corporate group as a vehicle for obtaining a large amount of corporate capital and senior management support, and therefore was in direct competition with the energy conservation engineer for resources. It appears that he believed that a link between safety and energy conservation was not about the way they understand safety in Transitech, but about the high status and power accorded the corporate safety group. Therefore, he appeared to believe that it was dangerous to his interest to establish a link between energy conservation and safety. If that occurred, his chances of
attracting resources would decline. Therefore, he had to undermine the argument. He was very successful, though he almost destroyed the group in the process.

Influencing the process

From the above discussion, it should be clear that there are four ways in which people can try to influence the story which emerges out of the sense-making exercise. The first is to try to influence the process by which the sense-making occurs. Unlike individual cognition, which happens automatically and unconsciously, organizational sense-making occurs in structured environments. The structure of the process can presumably affect the outcome (this is the case of changing the rules for the investigation). The second is to dispute the 'facts' -- the image schemas that form the building blocks of the story. People can contest what events did, or did not, happen. This sort of action is unlikely, since there is generally a consensus or lack of witnesses here. The third is to contest the way those facts are aggregated, what propositions are used to link them, and the relative emphasis to place on the various propositional linkages. Finally, as we saw above, people can attempt, retrospectively, to change the weights placed on the various elements of an agreed-upon story.

Change by selection

Surprisingly, change by selection was an important component of the Wideplant change effort, even though the company traditionally hires people for their entire working lives. The organization change happened to coincide with the period when all of the initial employees retired. Therefore, management had an opportunity to hire for a very different set of employee characteristics when it replaced them. It did. Similarly, there was a lot of strategic movement of people around the plant site so that people who didn’t understand the change effort would be out of the way (in places like the central mechanical shops).

Selection, with adaptation, providing flexibility

There are at least three ways in which the flexibility created by invoking a selection-based change alongside an adaptive change facilitated the change process. This is in addition to the straight flexibility effects that facilitated change -- such as the increased access to plant-level information that managers had because of the existence of the union. These were discussed in chapter 12, and won’t be repeated here.

The existence of the prototype plant

The first way in which flexibility induced through selection was important was through the existence of the prototype plant. In essence, by having the prototype facility on the site, management was able to show people that there were other possibilities for work organization than the one they already had. This had a number of effects. The first was the straight “selection” effect. That is, there was an alternative model that people could imagine instead of the organization that they had.
However, there were also a number of "flexibility" effects. That is, the existence of the prototype increased the ease with which adaptation could occur. First, once people had two models for the way the organization could be structured, there was the possibility of many more. That is, they could use the two models to generate a whole lot of hybrid models. This led to further inquiry and deeper understanding. Second, the existence of the prototype significantly reduced the possibility of resistance because it changed the rules of the game. People were able to see that the prototype was successful, and therefore had to frame their objections in terms of it's design, rather than the original design.

**Autonomy of actors**

The second way in which the use of selection induced flexibility which was vital for the change was seen in the flexibility chapter with the discussion of maintenance scheduling. As we will see in the next chapter, at a given time in the change process, the various members in the organization will span a spectrum in their commitment to the change effort or understanding of what is required. The organization must be able to accommodate such variance. By having a number of people who can take responsibility for action, the chances of someone who is committed to the new organization being available to complete some task that relies on the values inherent in the new organization is increased markedly. This is particularly true if people with those values can be imported through recruiting efforts. Once people can see a colleague performing the task and adopting the principle, there is a much greater chance that they will adopt the principle also.

**Organizational robustness**

The third way in which flexibility can be vital for the change effort is through the possibility of things falling through the cracks. A flexible organization is likely to be more robust. As an organization goes through a transition, things are likely to be overlooked or forgotten or contradictions are likely to not be noticed. That is, there will be many unexpected side effects. By having an organization in which multiple actors can act, the chances of someone acting, when it is important but not formally required, are enhanced significantly. We saw this particularly in chapter 12 with the discussion of controllers having a choice in the people to whom they took safety concerns. Once the concern has been raised, it is possible for people to then go back and understand how it is that the design faciliated the problem in the first place.

**Conclusion**

In this chapter I have described the various strategies people in the two plants, but mainly at Wideplant, used to bring about the desired organizational changes. I argued that they had a broad choice between selection and adaptation based approaches. There were three basic adaptation strategies: teaching, changing the rules, and exploiting opportunities to redefine the organizational reality. In addition, by using selection and adaptation simultaneously, the organization created flexibility that both facilitated the change and increased the organization's robustness during the change.
16. Barriers to change

In this chapter I lay out the barriers to change which I observed in the plants. To frame the discussion, I discuss them in terms of a decision to try to persuade a group of operators to adopt a new principle which guides their work. However, many of the barriers I describe can be expected during other phases of the change I describe and when using other strategies. First, we will examine the sorts of barriers we can expect to see if the group of operators are asked to adopt such a principle, independent of the rest of their experience in the organization. Then, we will examine the barriers that result from the fact that change is attempted in the context of ongoing organizational activities, and embedded in a history of interactions.

A model of the adoption process

Imagine that Olivia, an operator, is asked to implement a new principle. I contend that she has to complete three tasks before full implementation has occurred. First, she has to 'buy-in' to the idea of the new principle. That is, she has to see it as a sensible idea that invalidates her previous ideas. Second, she has learn what it means. That is, she has to learn how to generate rules for behavior from the principle, or at least understand the rationale behind the rules she has been asked to follow. Third, she has to learn the domain to which the principle applies. That is, she has to understand when one principle matters and when others take precedence. While this is the logical order for completion of the three tasks, they undoubtedly overlap. When she has completed all three tasks, she will be able to apply the principle intelligently. Subsequently, we expect it will be absorbed into her set of assumptions about truth (Bourdieu 1977; Schein 1985) and disappear from consciousness.

Buying in to the idea of the principle

To buy in to the idea of the new principle, Olivia has to see it as legitimate. Olivia is a member of a group, process operators, and different members of the group will see the principle as legitimate for different reasons. I will assume that they exhibit similar behavior to the adopters of technical innovations. The members of the community will vary in the rate at which they see the principle as legitimate, and therefore the rate at which they buy in to the idea of it. They are likely to adopt the principle in four distinct groups. In temporal order, there will be immediate adopters, opinion leaders, the followers, and then those who never adopt (cf. Rogers 1983). Each group will use different criteria to determine whether the principle is legitimate.

The 'immediate adopters' will be people who see the principle as legitimate immediately, and who thought the old principle was illegitimate. That is, they worked under the old principle under duress. We can predict that the very earliest adopters will not identify with the rest of the process operator group at all. They will not look to the group for validation of the principle. Instead, they will look to the content of the principle itself. Therefore, they will accept it independent of any contextual variables. So, for example, at Wideplant, the engineers had no trouble getting the younger controllers to take on an enormous
amount of responsibility in the design and implementation of engineering projects. These controllers were hired because they believed that this was a legitimate part of process operators' work. However, it was much harder to get the older controllers to participate actively.

Interestingly, we also expect that this first group will have trouble with the other two tasks (learning what the principle means and the bounds on its applicability) because they will not appreciate the extent to which the principle is organizationally contingent. For example, one trainee was constantly frustrated because he felt shackled by management. He really wanted to learn how to program the data logging system in the DCS. However, he couldn’t understand why the site computer people wouldn’t take the time to teach him, and why management wouldn’t support his desire to take a course on it, or even provide him with appropriate manuals.

The 'opinion leaders' are the key players since they hold open the gateway between the main group of operators and the change agent. They are likely to see the other operators as members of their reference group, but accord the principle legitimacy on the basis of its merits. For them, however, some sort of reframing will be needed before they can integrate the principle, because they will have been socialized to accept another principle which is presumably antithetical to the one being proposed.

For example, we saw in chapter 6 that one of the senior controllers complained to me that he objected to being asked to write a complex new maintenance procedure. While he found the work engaging, he thought it was not legitimate for the company to ask him to do any work which he had to think about after he left the plant. For him to buy in to the principle completely, he would have to change his conception about the relationship between his work life and his home life.

Note that the schema which has to change is not the one that is central to the principle (that controllers should design procedures -- a fairly macro rule that follows pretty directly from the principle) but is one that follows as a consequence of the principle's interaction with the context. He can reject or accept the macro principle without reframing his assumptions (or leaving the airport bookstore). The principle itself is very straightforward. However, once he tries to implement it, he sees a conflict with his prior assumptions.

For each different controller, different sets of issues may need to be worked through before the principle will be considered legitimate. Some, for instance, thought it was not legitimate for the company to make them do day work because it infringed on their social life by changing their schedule away from their friends'. Others objected to not being able to predict their days on and off a full year in advance, which they had been able to do for the past 15 years.

As we move through the operators from the 'opinion leaders' to the followers, the reason for according the principle legitimacy is likely to shift. People will become less concerned with the legitimacy of the principle per se, and more concerned with what the rest of their reference group thinks about it. This group will begin to see the new principle as legitimate only after the opinion leaders have started to adopt it fully. For example, toward the end of the field work, the mood of the area 'B-C' controllers to the day rotations appeared to be changing. Instead of being against it outright, as they had claimed to be when I first visited the site, a sizable number were starting to say -- in ever so quiet voices -- that they quite enjoyed the challenge of the day work and the chance to work with a different group of people, but that they hated other aspects of it, particularly the disruption to their normal life and the loss of pay.
Those who never accord legitimacy to the idea of the principle will belong to a different reference group. Most likely, they will be older operators. For example, in chapter 10 we met a controller who refused to remove icicles because he claimed that that was not part of what an operator does. In essence he was refusing to take any responsibility for the work or ensuring it was done.

Determinants of legitimacy to the opinion leaders

Let's assume that Olivia is a potential opinion leader. Initially, she doesn't see the principle as 'natural'. Instead, she has to trust, to a certain extent, that it is legitimate. Olivia has to 'try it on for size.'

I hypothesize that three things determine whether she sees the novel principle as legitimate. First, there is the extent to which she trusts the person who is advocating the principle. If she believes the person does not have her best interests at heart, she is much less likely to entertain the new principle seriously. So, if the person has a political motive, or if Olivia believes they do, she is unlikely to take the issue seriously. In this context, we see the importance of the problem of people making attribution errors (discussed in chapter 10). We saw at both sites, that people would misattribute motives, and therefore create political conflicts when none existed. This is likely to be a major inhibitor of trust and therefore the likelihood of the new principle being considered actively. We saw also that problems of attribution error were much worse at Highplant than at Wideplant.

Second, the principle has to seem intrinsically legitimate. We saw in chapter 11 that Olivia could understand the principle in one of three ways. She could understand it practically. That means that she somehow sees it as having a logical basis. Alternatively, she could understand it formally. That is, she sees it only in terms of the behaviors and rules which it implies, while she doesn't understand it. Third, she could understand it accretively. She would see it as something completely divorced from the rest of her experience. The eventual aim is to have her understanding it practically. However, we know that will not be the case initially. The question is how to induce the schema change to get her to that place. We saw above that management is likely to attempt a cognitive and a behavioral approach simultaneously. That is, they will tell Olivia what to do, and they will tell her what it means. If Olivia sees the world in a fundamentally formal/accretive way, we cannot expect her to make the necessary transition. That is, she will learn the behaviors associated with the principle, but she will learn it as a series of rules, never as a generative principle. Therefore, she will never make the transition to accepting the new principle. We saw in chapter 11 that people at Highplant were much more likely to see the world in a formal/accretive way. If this is a reflection of their cognition (rather than a conscious recognition by them of the power relations in the site), it follows that they are likely to be less able to see the new principle as

1 It is important to realize that recruiting into the plants was far from uniform. Over time, the labor requirements for each process decreased. Therefore, recruiting only tended to happen when major new processes were added or when large groups of operators retired. Therefore, the operator groups in both plants consisted of three distinct cohorts with 0-5 years, 10-15 years, and 25-40 years of service.

2 We will see in chapter 17 that the sense making which can change organizational definitions occurs (almost by definition) in the most politicized activities in the organization. These are the times when trust will be tested.
legitimate.

Third, Olivia has to have experience with the proposed principle. That is, she has to see it in action. If the proposed principle runs counter to prior assumptions about the world, then she has to feel safe using it. That safety can only come experientially; by applying the principle and seeing first, that it works, and second, that nothing bad happens.\(^3\) For example, Wideplant was trying to operate on a principle of 'minimum inventories'. Most of the controllers and mechanics were very skeptical of the idea because there was always a shortage of parts. In part, they got around this by having little caches of spare parts hidden around the plant. However, sometimes the system became unstuck. We saw this with the safety shower example in chapter 10, where it was going to take months for the supplier to get the correct shower fittings. I think it is reasonable to assert that none of the Wideplant controllers and mechanics was on a trajectory to incorporating the principle cognitively. And, they had good reason. The spare parts supply simply wasn't reliable enough to support it.

\textit{Learning what a principle means}

Olivia's second task is to learn what the principle means. In part, this is linked inextricably to the third task -- knowing the boundaries on its performance -- since very few organizationally-constructed principles are universally true. And, in part, it is linked to the first task. Only when people start to see the principle in action, with no one being punished for it, can they believe that it is an acceptable guide to action. Therefore, enactment of the principle by someone in the organization whom Olivia respects (possibly herself) is a necessary precondition for her learning what it means. However, the task of learning the meaning of the principle is also important by itself. It is one thing to have an abstract principle. It is another thing to have something which can be operationalized in the local context and be used to generate behavior. Management generally makes it easier for people to learn the principle by prescribing some of the action (through the new behaviors) and by rewarding appropriate initiative.

\textit{Learning the domain of a principle}

Finally, Olivia must learn the domains to which the principle applies, and where the organization is going to give this principle dominance over others. Consider, for example, the differences in the way that the two sites constructed the domain of 'safety'. A quick walk through the cafeterias indicates immediately that one site puts much more emphasis on healthy eating. The mean weight of the senior management at the two sites appears to indicate that the need for regular exercise is part of the definition at one site, but not at the other. Furthermore, the two sites placed the line between individual privacy and the site's needs to minimize its safety statistics in a different place. For example, at one site, when an engineer broke his ankle playing volleyball, the business manager hauled him into the office and asked when he was going to give up these dangerous pastimes. At the other site, when an engineer broke her leg after her horse was startled by a deer, the business manager was shocked when I asked if he was going to 'talk' to her about it. He had nothing to say, other than that he hoped she would get better soon.

\(^3\) Remember that Olivia is an opinion leader, and therefore can't experience the principle vicariously.
The example above illustrates that principles are not 'natural'. They are constructed by the organization through its power relations and action (Lakoff 1987; Latour 1987). Therefore, Olivia must learn when the principle applies and when it does not. If we examine behavior in the organization, we see that people are constantly looking for clues as to the organizationally sanctioned ways to manage the conflicts between objectives, and therefore draw the line between them. For many years, Transitech had invested a huge amount of money in its safety systems. Because of competitiveness problems in the mid-1980’s, Highsite management changed its usual principle, “Safety is the most important thing we do” to a more rounded one, “Safety and production are equally important.” Safety performance fell for about five years until management re-instated the original principle.

Summary

The above discussion of the integration of a novel principle by the operators suggests seven key observations. First, adoption of the principle will not be instantaneous in the operator group. Rather, some people will accord the principle legitimacy immediately, others will take longer, and some will never buy in. Second, different people sign on for different reasons. Some look to the principle itself while others look to their reference group. Third, the initial legitimacy of the principle to the opinion leaders in the reference group is likely to determine how quickly the whole group buys in to it. Fourth, three things will determine the initial legitimacy to the opinion leaders: the extent to which they trust the change agent, the intrinsic legitimacy of the principle, and experience of the efficacy of the principle. Fifth, some people will never accord the principle legitimacy. Sixth, we cannot predict all the specific barriers to adoption of a principle in advance because they are so contextually embedded. Seventh, a significant part of learning what a new principle really means in practice and what the limits are on its practice comes from experimenting with it and from observing it in use. Any change process must take these seven observations into account if it is to be successful. Implicit in these seven observations are a number of potential barriers to change (e.g. lack of trust) that do not need elaboration.

Having discussed why management cannot reasonably expect any particular operator to have bought into a novel principle at a given time, in the next two sections I will show why the operators cannot reasonably expect management to be clear about what it actually wants! In the first section, I will discuss the barriers that are created by the need for ongoing production through the change. This means that management cannot afford to remove the old objectives too soon, or an organizational failure will occur. In the final section of the chapter I will discuss the implication of management itself facing intrinsically conflicting objectives. I will present four broad reasons why this is the case. These all create another set of barriers.

The problem of ongoing production

Consider Matthew, a manager who has been asked to run a process area and implement a change program. The program is half-way through. Some of his operators have bought into the new program, but the vast majority have not. Last night, a fight broke out between two of the crews about which crew will send someone to days next (an example from the data). He suspects that the basis for the problem is that some of those who have not bought in have developed a habit of ‘free riding’ on the freedom offered by the new program. The more conscientious will, once again, have to bear the cost if he lets them get away with it. What
does Matthew do? Does he tolerate the inappropriate behavior because his boss keeps telling him that it will go away once people start to feel ownership for the operation, or does he take control, going against all the rhetoric, to make sure they keep putting out the pounds, peace is restored, egos stay intact, and no one gets hurt? This is probably the fundamental judgment call the managers at the two plants had to make. And, they made it several times a week. Given a particular decision, should they operate under the old logic, or under the new? Because the change effort was more salient, it was a bigger problem at Wideplant.

We struck this problem once before in chapter 9 when I discussed the problem of the production coordinators’ power. We saw there that the production coordinator determined how much discretion for action the operators and controllers had. As such, the production workers’ power was contingent on management giving it to them. This was the old system in action. We also saw that, in a number of ways, the Wideplant controllers had more power than their Highplant counterparts. They were listened to more, they had better access to both information and decision-makers, and they were more likely to be present when the important decisions were made. This was the new system in action.

One of the constant negotiations between the production coordinator and the controllers was over the boundary between these two systems of power. Whenever the controllers thought they had been wronged by the production coordinator, they let him know very clearly. Whenever the controllers overstepped their line, they were told so in no uncertain terms. Of course, every time this happened, the controllers would accuse management of insincerity about the change program. They would claim that it was all rhetoric, and that nothing was really changing at all. This would create an extra set of antagonistic interactions which management had to manage.

Matthew faces the additional problem, however, that he wants to move the line at different rates for different people. Unfortunately, because there are norms of horizontal equity and a need for manageability, there can only really be one line. The result at Wideplant was that some people were free riding because the system was too loose. The cost of that free riding was borne by the more conscientious members of the organization. Others complained because they felt that the system wasn’t loose enough. This was essentially the basis of the complaint by the controllers that management’s talk of empowerment was just that, talk.

One of the major crises at Wideplant arose from a free-riding incident. However, the infraction was not committed by a disillusioned controller, but by one of the opinion leaders for the change effort. One Saturday night, the plant had the biggest snowstorm in many years. The relieving crew, whose members all happened to live many miles away, was not able to get into work. According to the procedure, and long established practice on the site, overtime should have been called in. Because of the tremendous pressure on fixed cost, overtime was valued highly. The crew which was eligible for it had all risen early on Sunday morning to shovel three or four feet of snow from their driveways and wait for the phone call. However, the call never came. Instead, the crew which had worked through the night decided to stay on during the day. The decision incidentally cost the company several thousand dollars in extra wages. This led to a big outburst at the Monday’s morning meeting and precipitated a crisis in the organization.

This was a crisis for two reasons. First, it was the first time that anger over the restructuring was directed by one crew at another, instead of at management. Second, the leader of the crew which had stayed the extra shift was one of the most enthusiastic supporters of the changed work organization. The solution the organization developed was novel. Whenever, during the next year, the perpetrator of the “crime” had to take time off his regular shift, mainly to attend meetings on the work reorganization which came, in part, out of this incident (see chapter 18), the leader of the crew which had been slighted would be called in to work.
overtime. I was unable to determine how deliberate the strategy was, but several people (management and labor) commented to me each time that the offended controller was getting his retribution.

The result of all this seemingly random behavior by management was that Wideplant morale was very low. From what I could ascertain, there were three reasons for this. First, the controllers had to work under much more ambiguous conditions than they had in the past. Not only was the new work intrinsically more ambiguous, but the messages management was giving appeared to be (and necessarily were) extremely inconsistent. There seemed to be no pattern to the decisions which people were allowed to make, and those which they were not. Second, the organization had a feeling of being out of control. If management let the reins go slack for too long, people would start to act out (principally by passing problems on to the next shift) and discipline would fall. Therefore, the organization lost the orderly predictability which it had had in the past. Third, the free riding itself was causing a lot of resentment among those who bore the extra cost. In essence, the controllers felt like the place was 'going to hell in a hand basket', even though the performance appeared to be quite good. As the opinion leaders' morale dropped, their enthusiasm for the change effort did also, and so they became decreasingly likely to extend themselves to try to make the new organization work. However, if you asked people, they would universally say that they didn't want to go back to the old system.

Conflicts between objectives

This section describes four different types of conflicts between objectives. All four indicate why Matthew cannot say unambiguously what he wants of the operating staff. The first and second conflicts derive from the fact that an objective is a type of contract made in a highly equivocal environment. A person with power suggests an objective. In return, people subject to that objective promise to satisfy it. In return, the person with power promises to reward them if they succeed. Because the environment is equivocal (Daft and Weick 1984), the person subject to the objective isn't sure whether the person making the promise really means it, or whether they can deliver on their promise even if they do.

Shifting environments mean shifting objectives

As the organization's environment shifts, so does the appropriate objective. Therefore, the person who holds the power must keep changing the objective to satisfy shifts in the environment. Consider, for example, the objective of profit maximization. Any reading of economics, or its more organizational alternatives such as agency theory (Alchian and Demsetz 1972) would lead us to think that this is the least problematic of objectives. Given a discount rate, people should be able to work out the appropriate actions to maximize returns. This should be especially true in a "compound" facility which makes one product, maximizes returns when it is going, and costs a lot when it is not.

Over the course of the study, four qualitatively different objectives, all of which would seem to stand for maximum profits, were used at Wideplant. At the start of the study, two objectives were in use. The first was "uptime", the portion of time that the plant was running. Each percentage point of uptime in the plant was worth well over a million dollars per year in revenue. Uptime is an obvious measure of the overall competence of the management and
operation of the plant. Because the plants were competing to see which would be tasked at
capacity, and which would be the "swing" plant, it was important that they have high uptime
numbers. One would think, a priori, that uptime would be unambiguous. In fact, it is very
difficult to determine the denominator term, the total capacity of the plant, because there are
1) forced outages for cleaning and maintenance, 2) outages nominally beyond the control of plant
management, and 3) different interpretations of the maximum throughput of the plant because
the technology is changing constantly. Each shade in meaning leads to different optimal
behavior. For example, under one definition, if the dryer breaks and you fix it, and then make
your monthly production quota, you can allocate the time to lack of demand rather than
mechanical problems, and so get a higher uptime number. Under another definition, you cannot.
The plants fought for months over an appropriate definition, and eventually resolved the
problem by one plant reporting two numbers: the one the staff believed was their true uptime,
and one calculated using the basis of the other plant's algorithm.

Another measure was total fixed cost. At the start of the project, the business would
task the plants on this basis. That is, they would use the cost per pound of product for labor,
parts, and working capital. In other words, everything except depreciation and raw materials
was included. This put tremendous pressure on management to minimize the total number of
people involved in the production process, maximize reliability, and drive both overtime and
absence levels to zero. Until just before the end of the study, Wideplant management pushed
very hard on these. Then, it all changed. The "compound" business decided a more appropriate
algorithm for tasking the plants was incremental marginal cost (the one the economists would
predict). Suddenly, the marginal efficiency of the plant became much more important than the
fixed costs, and so there was a renewed emphasis on cost savings through efficiency gains and
energy conservation.

Finally, early in the study, corporate management threatened to shut down one of the
processes on Widesite. Eventually, the site team prevailed in intense negotiations with a
Corporate team. Coming out of those negotiations, the site manager was able to determine the
metrics that the corporate managers were using to assess the viability of the business. He
immediately made these the objectives for the plants on the site.

In other words, shifts in the external environment meant that four different measures of
plant performance were important, often two or three at a time, in determining how well the
plants were running: uptime, fixed cost, incremental marginal cost, and the site manager's
objectives. A person who works to satisfy a given objective never knows how permanent it is.

These shifts had big impacts on the controllers. The first was that management's
efforts in overtime reduction meant big pay cuts for them. Most controllers lost $10 - $15,000
dollars annually as a result of management's decision to aim for zero overtime. In addition to
the obvious financial loss, this combined with attribution errors to create two big problems for
management. First, because the push on overtime was contemporaneous with the start of day
rotations, the controllers misattributed the pay cut to the day work. They said that the change
cost them $5-6,000 for a six-month stint. In fact, excluding differences in overtime, the
difference was closer to $2,000 (from loss of public holiday loadings). Not surprisingly, the
controllers objected violently to the move to days because they thought it was costing them so
much.4

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4 If the move to days was reducing their access to overtime, then the people working shift
would get extra, and so it could be expected to average out.
The second attribution problem was to the messenger. As noted several times above, many of the controllers had very little perception that the organization extended terribly far beyond their immediate supervision. Many of them thought that the personnel facilitator was fundamentally evil for deciding to put all this pressure on overtime, and therefore docking their pay. They had no conception that the push was coming from much higher up, even though all the plants on the site were under the same pressure. This meant that the personnel facilitators had a particularly miserable time at work, and tended to become the scapegoat for people’s anger (See also Hirschhorn 1988).

_A shifting environment means no promise is certain_

A shifting environment also makes objectives ambiguous in a second way. If the environment is shifting, the person with the power cannot necessarily guarantee that they will be able to dole out the promised rewards (cf. Zahavi 1973). Consider again the business which was almost shut down. Site management had consistently promised the employees a job if their plant was the lowest cost, safest, highest quality, and most flexible operation in that business in the corporation. This promise was absolutely central to the change effort since it was the source of all the good will and tolerance from the controller group. While this may seem reasonable from a rational perspective, it is not necessarily the case in the corporate world. The Widesite plant was better than the corporation’s other major operation on all four dimensions. But, it was much smaller, and the other plant was in the corporation’s home country. Therefore, when top management instructed the business to shed cost, all eyes turned to Widesite. Eventually the site manager persuaded a senior vice president from a third country that they were contracting out work for more than the Widesite’s product cost, so they "shut down" half the Widesite operation, turned it into a contractor, and brought the contracted work back in-house. While the story has a happy ending, it also illustrates that in an organization with politics and power games, it is very difficult for a person at any level in the hierarchy to promise anything. Therefore, someone responding to a request from someone in the hierarchy must also consider that person’s ability to stand behind their promise, as well as the promise itself.

This was the basis of the opposition of the union’s parent to the workplace reform efforts at Widesite. As the representative explained to the Transitech representative to the contract negotiations, the old system protected the worker. The worker assumed that management didn’t care, and if he lost his job, he could just get angry with management and move on. But, in this system, management wanted the worker’s heart and soul as well. If the experiment was a failure, the people would be destroyed.

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5 Geographical location had three implications. First, the people in the home country plant almost certainly had better access to high-level corporate decision makers. Second, people at Widesite believed the corporation tried to avoid layoffs in the home country if it possibly could. Third, the financial structure of the corporation and the subsidiary were such that shutting down a plant in the subsidiary didn’t have as big an effect on the corporate parent.
Different bosses make different promises

While the first two problems dealt with the equivocal nature of the environment that the person who responds to the objective works in, the second two deal with its uncertain nature. The third problem is the problem of hierarchy. That is, in an organization with multiple hierarchical levels, people report up the line to many different people. Consider, the conversation where an engineer told me that when management launches a new program, "We just use the new words for six months and keep doing things the way we always did." Initially, I was shocked. I even resolved to write a short piece for practitioners on the importance of understanding the meanings behind the jargon in new corporate programs. If people presumed that the corporation had a reason for spending all this money, they could learn something. They could use this learning to impress people and further their careers.

A couple of months later, I realized that I was not necessarily right. It wasn't necessarily in the engineer's interest to understand and implement the new program, even if corporate management wanted her to. She had a boss. At one level, her job was to behave in a way which her boss found acceptable. If the boss didn't understand the new program, or thought it was a "flavor of the month", or thought it was irrelevant, her job was to do what the boss wanted, not what someone ten levels above her boss wanted. Therefore, the most intelligent thing she could do may well have been to adopt the surface manifestations of the program, continue to act the same way as before (cf. Meyer and Rowan 1977), and watch to see what happened. After watching three or four times, she might have concluded that watching was a waste of time too. Therefore, she would go routinely to mindless adoption of the words without the thoughts. Of course, the boss was in the same position. Should he have taken the program seriously, or looked to his boss for clues? It gets more complicated, however. People in corporations have multiple allegiances. It also may have made sense for the engineer to go around her boss and please another person by taking the program to heart. 

There are many objectives.

The second form of uncertainty comes from the fact that there are multiple objectives. Plants must be safe, environmentally friendly, profitable, quality producers with happy employees with an appropriate racial and gender mix, performing ethically. Furthermore, they must satisfy the demands of institutional actors. So, they must comply with the law, comply with corporate directives, obtain an ISO quality certification, obtain a corporate maintenance certification, implement certain workplace reforms, have monthly safety meetings -- whether they contribute to safety or not -- and so forth. These objectives are not necessarily equivalent and cannot all be satisfied at once.

In fact, some of the objectives, if taken at face value, are inherently in conflict. The

6 It is important to note that I have no evidence that the engineer, or her boss, was aware of this dilemma. In fact, given the formal rationality and institutionalization which dominated the way other programs on the site were tackled, it is more likely that she simply assumed that corporate programs were things to be done, but not taken seriously.

7 This also suggests that it is very unlikely that organizations can engender any real top-down change if they have more than about five layers of hierarchy.
most important example of this is the two change objectives in place at Highplant at the time of the study. One was a strong directive from corporate management -- essentially through the manufacturing organization -- to improve safety performance. It was assumed that this would be done through the implementation of traditional corporate safety practices. The second was the strong push -- mainly through the business organization -- to put the Wideplant work system in place. The traditional safety management system, which relies on fear and low trust is inherently antithetical to the assumptions underlying the transformed work system.

Not surprisingly, given many objectives, some are taken seriously, and others get just a surface treatment. For example, a few months before Highplant received its ISO quality audit, the plant leader said at the morning meeting, "It is very important to use and document the systems before then". The implication for what should happen afterwards was clear, and was apparent when I visited the site soon after the certification was obtained. People weren't so concerned about ISO anymore. They had moved on to 'Maintenance Excellence' certification.

People look around for cues as to which objectives they should take seriously, and which ones they should not. We saw this clearly above, when managers at Highplant interpreted a change in rhetoric from "Safety is the most important thing we do" to "Safety and production are equally important" as an excuse to let safety standards slip.

So, there are two major reasons why the production workers cannot hope management will be unequivocal in the objectives it sets. First, management is responsible for ongoing production and the change effort. Ongoing production is built on the old logic and the change effort is built on the new. Management must create a highly equivocal environment by advocating and using both logics simultaneously. Second, all the objectives are ambiguous and people are never really sure what is wanted of them. There are a four reasons for this: a changing external environment means that objectives must change, a changing external environment means you don't know if the person setting the objective can deliver, uncertain power relations mean you don't know whose objectives to satisfy, and conflicts among stated objectives mean it is unclear how you should act. All four of these later reasons are valid sources of concern for people who are asked to adopt a new principle.

Conclusion

In summary, four major problems were occurring during the change process. First, even if management and labor were totally committed to implementing the changes, as they implement the new principles, they would constantly experience conflicts between their prior assumptions and the demands of the new principles. Change is traumatic because it involves resolution of contradictory assumptions, either by schema changes or negotiation, or coercion. Second, even after implementation was complete, let alone before, management could not expect all the people in the organization to believe in the new principles. At any given time, the organization spanned a continuum from converts to cynics. We saw seven important implications of this for the design and implementation of change. Third, managers were trying to operate in the new organizational world and the old organizational world simultaneously. This created a tremendous amount of confusion and morale loss because people are never sure whether their bosses are really serious about implementing the change. Finally, because of conflicts between objectives, people were never sure what, exactly, was wanted of them.
17. The role of politics in sense making

In chapter 14, I argued that people understand their organizational world (and the rest of the world for that matter) in terms of proposition schemas and image schemas, with proposition schemas describing the relationships between the image schemas. I concluded that there are four different ways in which can change their understanding of the organization. They can redefine image schemas, they can redefine proposition schemas, or they can change the strength of the coupling implied by proposition schemas. Finally, as people's comfort with a given proposition or image schema changes, they will hold it more or less consciously. That is, the depth to which they hold it will change. People who wish to act politically to influence the way the organization evolves can challenge any of these directly, or they can change the process the organization uses to determine causal relationships by changing the sense-making procedure.

In the previous two chapters we have seen that there are major obstacles to gradual change. Management's ability to use selection approaches was limited by its ability to move old people out of the way and bring new ones in. Similarly, teaching people new rules often resulted in institutionalized behavior, and new principles weren't always received at face value. Finally, changing the underlying rules which generate action only took people so far. In this chapter and the next we examine what was possibly the most effective strategy for bringing about change, since it was the only one which explicitly brought assumptions to the surface and made them available for negotiation. Therefore, it created a context in which the organization could resolve the conflicts between different groups' objectives and understandings. In particular, I will argue that formal learning events were occasions in which the different groups in the organization competed to define the meaning of events, and through that competition created the organization's self-definition. That is, it was through their learning about supposedly technical matters that assumptions about interpersonal relationships were brought to the surface and negotiated. As such, learning in the organizations was inherently political.

I will make the argument two stages. In the first (this chapter) I will argue that sense-making exercises were inherently political. In the second (the next chapter) I will argue that the outcomes of these exercises could lead to organizational change, and did in three of the four cases I examine.

Accidents and coupling

The venue in which we will examine this is in accident investigations. These are an important place to look for two reasons. First, an incident investigation is essentially a process of deliberately deconstructing the organization's causal map. It is deliberately taken apart and then recreated. Second, because of its emphasis on safety, investigations are important symbolic event in Transitech's production sites and the stakes are very high. Therefore, they are a place where people can see management's true commitment.

We saw in chapter 3 that an organization comprises a large number of system elements coexisting in a social space. In chapter 8 we added the elements of the environment which penetrate the organization's boundary. These systemic and environmental elements included
the technological hardware, the operating procedures, the personnel system, the people, their attitudes, the pension plan, and the weather, among other things. We saw that many of these elements are coupled tightly to each other, others are loosely coupled, and some are decoupled. However, even the loosely coupled and decoupled elements are interacting. I then defined an accident as an interaction, or series of interactions between elements that were previously thought to be independent, such that energy is released and damage is done.

Sense making and accidents

A given accident is preceded by a large number of these interactions. Many are partial causes of the accident and many are loosely coupled to each other. When the organizational members make sense of the accident, they must decide which of these prior interactions are important, which to ignore, and which are related to each other. That is, they must trace a causal chain backwards from the effects to the causes. At Transitech, this process for determining causation was called an 'incident investigation'. An accident investigation started on the day of the accident with a preliminary meeting and ended a week or so later with a formal investigation. The findings were then codified in a written report.

At the start of an investigation, equivocality rules (Daft and Macintosh 1981). An 'effect', the accident, has a vast number of alleged 'causes' with an ambiguous relationship to each other and the effect. That is, cause and effect are loosely coupled (Weick 1976). The organization eliminates that loose coupling by constructing a story which couples cause and effect tightly. That is, they decide which events and objects (image schemas) are important and how those events led to the accident (proposition schemas). Often, this process includes the use of proposition schemas to aggregate images into 'macro images' called categories (Lakoff 1987)

This analysis focuses on four accidents which I argue are equivalent. That is, all involve approximately the same level of complexity and coupling of technical systems. Perrow (1984) would label all four as component failures. Also, most proximately, all involve the actions of one person working alone. Three of the four accidents are of approximately the same severity. The investigations from three of the four accidents led to changes in the organization. Gersick (1991) would describe them as punctuating events.

<table>
<thead>
<tr>
<th>Low Severity</th>
<th>Highplant</th>
<th>Wideplant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mike/Steam hose</td>
<td>Tim/Grating Danny/Steam vent</td>
</tr>
<tr>
<td>High Severity</td>
<td>Bill/MCC</td>
<td></td>
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</tbody>
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Table 17.1. The sample frame

In all four cases I gathered as much data as I could about the incident, the investigation, and people's thoughts about the meaning of the injury for their work lives. This generally had to be done fairly unobtrusively, under the guise of either conversation or as part of a limited number of formal interviews. I transcribed the four taped interviews relevant to this chapter, and coded them, along with all relevant observational and interview field notes and the official investigation reports, into the categories used in the analysis (i.e. in terms of the person who articulated the cause and whether they thought it was significant). Only one person needed to articulate a given cause for me to attribute it to a group, though most causes
were mentioned more than once. Where possible, the validity of attributions was tested during that discussion, during subsequent discussions with other members of the group, or with observations. In some cases I had to infer the codes from people’s statements, particularly when coding field notes. For example, in the investigation for Danny’s accident below, the area manager noted that Danny was a summer student and asked if this was the first time he had performed the particular clean-out operation. From this, I inferred that he was concerned that Danny was young, inexperienced, and unfamiliar with a lot of the equipment and procedures.

The four accidents

Highplant 1:  Mike and the steam hose

Mike, a trainee operator at Highplant was asked to steam a pipe to dissolve solids built up inside. He sprayed the side with a steam hose. A kink in the hose was making his work difficult. As he attempted to remove the kink, he lost control of the hose head and it whipped up and burned him badly under the arm.

Highplant 2:  Bill and the motor control center

A portion of the Highplant operation was undergoing a six-week shutdown to install a computerized process control (DDC) system, including about 300 new meters. Shutdowns are a 24-hour-per-day, seven-day-per-week operation since every day down costs between $100,000 and $500,000, depending on the availability of replacement intermediate products.

At about 4:00 pm on the hot and humid sixth Sunday, a process operator handed Bill, an electrician, a list of about 20 Motor Control Centers (MCCs) to reinstate to service. MCCs are boxes which connect motors to their power supplies. While most motors in the building were taken out of service for the shutdown, some were needed throughout, so power was being supplied to the switch room. MCCs have a main switch on the outside and contain fuses and other process electrical equipment. The MCC’s door has a safety catch which prevents it from being opened if the control switch is in the ‘on’ position. Although Bill wasn’t told to complete the work by shift change at 5:30, he is “the kind of guy who would”, and there was an air of anticipation and pressure to get the process back up. The reinstatement procedure required the electrician to physically lock the switch on the MCC in the ‘off’ position, put on a fire-proof jacket, gloves, and face mask and use a voltmeter to check that the system was electrically dead. He could then take off the mask and use plastic fuse pullers to reinstall the fuses. Finally, he could close the door of the box and remove his lock.

As was apparently his custom (and reputation -- though that may be a retrospective attribution), Bill chose a significantly less strict procedure. He walked up to the open boxes, put one end of a fuse in each of the three holders (one for each phase), and pushed them in, one at a time, with a screwdriver. Unfortunately, on one box -- which incidentally was not on the reinstatement list -- the built-in safety catch had been over-ridden and the door had been opened with the switch in the energized (‘on’) position. When Bill touched his screwdriver from the fuse to the side of the box, the resulting arc caused a flash fire which burned him extensively on the hands, face, and arms.
Wideplant 1: Tim and the grating

One cold and blustery February afternoon Tim, a Wideplant trainee controller, was ensuring steam hoses had been checked for degradation by examining their annual inspection tags. One hose was being used to clear a blockage in a poorly designed drain that had been causing problems all winter. Five days prior, another process operator had lifted the grate covering the drain, put the hose under the grate, placed a witch's hat on the hose to mark the tripping hazard, and had left it. Tim, making his way through the cloud of steam to the hose, walked into the puddle and stood on the grating. It pivoted on the hose, and he fell, up to his calf, into the boiling condensate, receiving second-degree burns to his leg.

Wideplant 2: Danny and the steaming vent

At the end of the Wideplant production process, product must be moved from one building to another. The solid crystals are kept in suspension by air introduced through booster jets in the side of the pipeline. Periodically, the line is cleaned out by introducing boiling condensate instead of product. The flow of lateral air is maintained to prevent the jets from clogging. At 11:55 one Friday evening, Danny, a summer student, and son of one the operators, was asked to check that condensate was flowing in the 'B' line, as they had just switched from the 'A' line, using a three-way valve. He did so and went upstairs to a field telephone to call in that the operation was successful. As he hung up the phone, hot condensate erupted from a vent about five feet from the phone, burned his wrist (which was not protected by his acid suit or gloves), blew off his glasses, and threw him to the floor.

Actors and causes

So, what caused the four accidents? That depends on whom you ask. With a given effect, and many interactions to choose from, the investigating committee tries to determine the cause/s. It does this by recreating cause-effect linkages back to the origins of the accident. The vast majority of cause-effect linkages come from their prior experience. For example, if someone gets an electrical burn, no one questions that a stream of electrons (whatever they are) arcing through the air somehow creates the burn. However, many linkages, particularly those involving interpersonal interaction, require detective work. Given a huge number of potential causes, the committee must winnow them down. It does this in two ways. On the one hand, it rejects some causes as irrelevant (i.e. not worthy of consideration) and others as inappropriate (i.e. relevant but overshadowed by other causes). On the other hand, it actively constructs the story of what it believes happened. In this section I will first present the official causal story -- the one management accepted eventually -- followed by the competitors. In general, the competitors are held by groups with different political positions in the system, such as the 'workers' or 'the union'.

Highplant 1: Mike and the steam hose

This case is relatively straightforward, however, much of the complexity may have been masked by my arrival on site after the event. It is standard practice that operators should use two hands when managing steam hoses. Also, Mike knew full well that steam hoses are
extremely dangerous pieces of equipment and must be handled with the utmost care. A moment's thought would indicate that it very dangerous to unkink a hose that is in use. Therefore, the investigation team concluded that he had failed to take appropriate care.

Some members of the hourly workforce disagreed vehemently with this interpretation. They believed he made a judgment error, and that it was a causeless accident.

On the other hand, Mike lacked experience with steam hoses. One recent study found that a large proportion of injuries occur in the first two years of service (Wells, Smith et al. 1991). Highplant safety managers agree with this finding. They see most accidents in the first or last three years of service, but that insight may have come after the Wells et al study and the accidents discussed in this paper, which both involve people in these two groups.

<table>
<thead>
<tr>
<th>Management:</th>
<th>Failure to follow standard practice</th>
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<tbody>
<tr>
<td></td>
<td>Failure to respect danger of steam hoses</td>
</tr>
<tr>
<td></td>
<td>Failure to pay attention</td>
</tr>
<tr>
<td>Co-workers:</td>
<td>No cause</td>
</tr>
<tr>
<td>Researcher/safety office:</td>
<td>Lack of experience</td>
</tr>
</tbody>
</table>

Table 17.2. Causal factors in Mike's steam-hose accident

Highplant 2: Bill and the motor control center

For management, most of this was straightforward. Bill violated one procedure by not locking out the equipment, then he violated another by not putting on his protective gear, and then he violated a third by not checking the system and by using the wrong equipment. Compliance with any of these would have prevented the injury. Furthermore, he tried to reinstate a box which wasn't on the list and failed to notice that it was switched on, both of which indicate he failed to pay attention. As one manager put it:

There is no excuse for an individual making those kinds of individual choices about doing their job unless it is a strange job or an unusual job, or for some reason he wasn't trained or he only does it every year or five years. Or it can be some extenuating circumstances. But, this one was right in the heart of what an electrician does all the time. And, to have that individual decide to do what he did is not acceptable. (manager's emphasis.)

Other people saw it differently. The investigating committee noted that someone had overridden the safety latch on the door of MCC, though it could not determine why. Another relatively central manager had two additional concerns. First, he worried -- as did Bill's co-workers -- that Bill was exhausted. Not only was it late in the afternoon, and at a point in the shift when someone's attention is likely to lapse, but Transitech's pensions are based on earnings for the three most lucrative years of service; generally the last three. Since he was three months from retirement, Bill was taking all the overtime he could. A manager's attempt to make everyone take off at least one day in fourteen (they are paid double time every seventh day) was thwarted when the mechanics on night shift asked the value of their sitting up on their night off and watching television (so they did not reset their internal clocks). The manager compromised and said the night mechanics should take some evenings off instead. The day mechanics interpreted this to include them, so Bill had taken off a few hours on the odd day to sleep in, including that Sunday. Notwithstanding, he had worked 42 days straight,
generally for 12 hours each day. After the accident, Bill said that he had "felt fine" that afternoon, and the manager accepted this.

The manager's other concern was that Bill had a doctor's appointment the next day for some important diagnostic tests. Bill claimed after the accident that he had discussed the tests with his wife and had not been worried. Again, the manager accepted this.

The other hourly employees had a number of additional concerns. First, the operators and mechanics are well aware of the extremely high cost of shutdowns and many said to me that they feel both external (from supervision) and internal (job satisfaction) pressures to hurry out of them. This could explain why Bill might hurry to complete the job even though he was not told to.

Second, employees explained that by the end of the sixth week, the whole work area was a mess of activity, tags, and confusion (cf. Perrow (1984)). In addition to installing the control system, four other classes of shutdown maintenance were being carried out: installation of changes in the process hardware (known as projects), mechanical maintenance, maintenance of electrical equipment such as switches, and required testing of the safety interlocks. The MCCs have to be worked on for many of these jobs, creating a constant flow of people through the room.

Mechanical and electrical equipment are 'tagged out' for maintenance, an exercise which requires cardboard tags and locks to be installed in key locations to prevent dangerous substances getting into the system (see chapter 10). Fuse pulling is part of a tagging operation. While a large tagging job, such as a shutdown, will involve upwards of 300 locks and tags, this one involved many more because they were installing a new control system. The large switch rooms in which the MCCs are located might contain the MCCs for half or a whole process operation. Many of the above jobs would have required tagging of the relevant MCC. Each required slightly different tagging because the motor, the switches and the interlocks, have different, and often contradictory, systems boundaries. Over time, old tags fell off and some tags were not pulled at the end of a job. Therefore, the tagging could not be guaranteed.

The employees' third observation was that safe work practices may have been poorly enforced. Enforcement on the site reached its nadir two years earlier. Since his appointment, the site manager had attempted to rectify this. However, a decade of poor enforcement had led to sloppy habits and poor norms. In addition, I observed that it was hot, humid, and late in the shift. These are hardly conditions conducive to putting on heavy hot protective clothing or being careful.
| Management:                           | Failed to lock out system  
|                                      | Failed to wear protective gear  
|                                      | Failed to check voltage  
|                                      | Failed to use correct tools  
|                                      | Went to wrong box  
|                                      | Failed to observe box was switched on  
|                                      | Power to building  
|                                      | Safety system on MCC over-ridden  
| One manager:                         | Tiredness -- Failed to take time off (rejected later)  
|                                      | Distraction -- Doctor’s appointment next day (rejected later)  
|                                      | Unsuccessful management of overtime levels  
| Co-workers:                          | Pension incentive system  
|                                      | Pressure to hurry  
|                                      | Poor enforcement of safe work practices  
|                                      | Noise, clutter and confusion in the MCC building  
|                                      | Time of day  
| Researcher:                          | Weather  

**Table 17.3. Causal factors in Bill’s MCC accident**

**Wideplant 1: Tim and the grating**

The interpretation process for Tim’s accident began quite differently. The Monday after the Saturday event, the business manager addressed his reports at their weekly meeting. These included Graham, Tim’s manager.

I'd like to pause and talk about safety. I think right now, we have to raise a definite yellow flag. I want to you talk to your people about where are we and where are we going. ...

I'd hope we'd talk about changes and how they might affect us. Like changes in (raw material) suppliers and weather, and the problems we have been having with the rail cars. We set up our fellow employees for an injury. Think of the changes people have to contend with. The backdrop to all this is (that) it's not by itself. Other things are involved. Like, job security concerns on site, pressures on overtime, pressures on absenteeism, lots of people off sick for legitimate reasons. The people who are left have to pick up the slack. They have to work harder and smarter. Plus, whatever else is impacting people. There is lots of snow and it is very cold. How about things going on at home, and in people’s families.

I gave this a lot of thought on the weekend. There is more than enough out there to distract people. Distraction is all that it takes to screw on a thread badly (referring to another incident), or put a hose in a grating the wrong way. These are signs of people who are doing their jobs and who are not thinking 100%.

"... [discussion of local problems] For instance, Glen, you have the Stan Smith thing (dying of cancer) which is on people’s minds. Graham, you have lots of disability in your area. Also, please, please, don’t decide not to do this because your area hasn’t had an injury or an incident. I think the conditions are there

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right now. Don, an incident like yours is unusual for that maintenance group.
...

These were the causes selected by the investigation team. In addition, we saw a number of more proximate causes in the description of the accident above. With the exception of the problems with the drainage design, and their manifestation as a puddle of condensate and a cloud of steam, none of these was seen as important, although they were the ones reported in the formal report. In particular, management didn't seek out or punish the process operator who put the steam hose in the drain and violated two standard practices: one by placing the hose under the grating instead of through it and one by failing to rope off the area.

A number of other violations were also discounted as contributors. In particular, three days earlier, on a routine safety audit, an area manager observed that steam billowing from the puddle of hot condensate in the drain obscured the hose. He requested that they rope off the area. This request was not implemented.

Finally, Tim was also an active participant in his injury. He chose to walk into the middle of a puddle of boiling water instead of going around the outside. Not only was this not mentioned in the inquiry, but I didn't even find out about it until some months later. The only criticism of his conduct came from the safety officer who said he should have laced his boots higher. Graham, his manager, rebutted that aggressively. Tim's lack of experience was never mentioned either.

The union disagreed. One of the union representatives on the investigation attempted to hold Graham personally responsible for not ensuring that the workplace was safe, for not following up after the audit, and for not coming to the investigation appropriately prepared.

1 It is important to note that the manager's narrow interests are better served by pushing blame down into the organization. As a senior manager, he is responsible for many of the factors identified here.
| Management (primary causes): | Poor drainage design  
Cloud of steam obstructed the view  
Puddle obstructed view.  
No one proactively roping off the area  
Problems with raw materials supplies  
Problems with the weather (snow and cold)  
Problems with rail cars  
Concerns about job security  
Pressures on overtime  
Pressures on absenteeism  
Sickness  
Need to work harder  
Family problems  
Cancer in the workplace  
High levels of disability |
|---------------------------|--------------------------------------------------------------------------------|
| Management (secondary causes): | Placing hose under the grating, instead of through it.  
No one proactively roping off the area  
Failure to rope off area after installing the hose  
Failure to rope off area after safety audit |
| Co-workers: | Choice to walk into puddle |
| Union: | Poor management by Graham  
Poor follow-up of audit by Graham |
| Safety officer: | Failure to lace boots properly |
| Researcher: | Lack of experience |

Table 17.4. Causal factors in Tim's grating accident

Wideplant 2: Danny and the steaming vent

This investigation was unusual in that the team did not identify any actionable causes. While they managed to develop a story which explained the accident that story ended with a "poor decision that was reasonable without the benefit of 20/20 hindsight".

The erupting vent was the pressure relief outlet from a 'cyclone', a box which was attached to the line they were cleaning. The air they were adding to the pipe had to be removed before the product was loaded for transportation. It would escape through this vent. Originally there was just a hole and a standpipe, but the designers had forgotten about the cleaning operations, and so, during cleaning, the pipe would "erupt" whenever there was a dynamic instability, particularly an increase in flow. They moved the cleaning operations to nights, so there wouldn't be anyone near the operation, and added the 'cyclone' to absorb these surges. Unfortunately, a design error meant it wasn't big enough, so they still had eruptions, albeit smaller and fewer. This problem had been identified six months prior and a new piece was being designed. In the mean time, "everyone knew" of the problem and avoided that floor during cleaning operations. Since the 'cyclone' was an improvement, the changes were never written into the short-term operations guidelines. The control room operator claimed he didn't warn Danny of this because he assumed Danny would use the phone downstairs (it was further to go, but on the way back to the control room) and because flow rates were dropping so no eruption was expected.

The standpipe was only one foot off the ground because they lacked adequate space. The field telephone was placed too close to the stairs because of space limitations and its prior
use. No one used that phone anymore. Due to the lack of phones, they were putting in extras as part of the construction project to replace the 'cyclone'.

The union disagreed. The union representative's main contentions were that there was a known risk at the site, and that it had not been actively managed. Furthermore, someone who was working in the area had not been told of the risks he should expect to face.

Finally, as they deliberated at length over whether the engineer had followed the correct procedure to redesign the 'cyclone' in a timely manner, I observed that the relevant procedure had no provision for managing risks for the six to 12 months between identification of a problem and final engineering and construction of a solution. This could easily recur in other incidents. Participants confirmed this afterwards.

<table>
<thead>
<tr>
<th>Management (Primary causes):</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management (Secondary causes):</td>
<td>Poor design of 'cyclone'</td>
</tr>
<tr>
<td></td>
<td>Poor location of telephone</td>
</tr>
<tr>
<td></td>
<td>Unavoidable, but poor design of standpipe</td>
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<td></td>
<td>Victim not warned</td>
</tr>
<tr>
<td></td>
<td>Poor labelling of three-way switch</td>
</tr>
<tr>
<td>Union:</td>
<td>Failure to remedy or manage identified risks</td>
</tr>
<tr>
<td></td>
<td>Failure to adequately educate employee</td>
</tr>
<tr>
<td>Researcher:</td>
<td>Lack of procedure to manage short-term risks</td>
</tr>
</tbody>
</table>

Table 17.5. Causal factors in Danny's vent accident

Making sense of sense making

But how did this happen? How can four equivalent accidents be attributed such different causes as the victims themselves, the weather, and 20/20 hindsight? In this section we will discuss the actions of the relevant actors, particularly the managers in charge of the investigations.

We can see from the above descriptions that no one disputed the facts. That is, everyone had the same image schemas. However, the various groups differed on the other dimensions. In particular, they varied on the way they aggregated the images to create categories, the propositions they developed to link categories, and the emphasis they placed on particular propositions in the causation story. Which story prevailed was a function, principally, of strategy and power.

Making sense at Highplant

In both Highplant cases, management and production employees saw the possible causes as coming either from the individual victim and the organizational context (cf. Nisbett and Ross 1980; Perrow 1984). That is, the various potential causes were aggregated into two categories: the victim and the system. If there had been some technical error, they may well have framed it as a dichotomy between the relevant engineer or manager and the context. When I suggested this to some operators, they disagreed, arguing cynically that management would never blame one of its own.
However, a propensity to frame the problem as one of agency versus structure is different from blaming the victim. The plants could have easily found fault deep in the technical system, or attributed blame to a "reasonable error". To see why they developed the particular explanations they did (that Mike and Bill were responsible for their injuries), we have to understand the managers' human resources strategies. As one manager explained (referring to Bill's accident):

An important piece of that (background which you need to understand) is that I have to have a very good safety performance. ... The nature of our operations are that they are very high hazard operations. If we make one small mistake here, the results could be absolutely disastrous. I have to carry the weight of that.²

As we saw in chapter 13, the site's experiment with highly decentralized safety management in the 1980's led to eroded safety standards. In 1990, an employee at another plant was burned badly while not following correct procedures. That plant's management refused to fire him in the face of strong corporate pressure because, while also decentralizing safety management, they didn't believe they had emphasized the importance of procedural compliance sufficiently. A team of plant managers which met regularly discussed this, and the Highsite manager decided to call a plant-wide safety meeting. The meeting included presentations from a senior corporate manager and the victim of the fire at the other site. At that meeting the site manager said, "'You follow the rules. If you don't, your job is in jeopardy.'" We now turn to the management's actions following the two accidents and see they are consistent with this philosophy.

Highplant 1: Mike and the steam hose

I was told by Mike and his supervisor that he was put on probation for six months and the supervisor lost that year's pay increment. A supervisor explained to me that both decisions were strategic. The case was marginal, but management was concerned because this was the second accident in the area within a year and it wanted to send a message that it is important to be careful.

This is consistent with other decisions on the site. I was told by three supervisors on different occasions that one supervisor was almost terminated when an employee died in an accident. Apparently three things saved him. First, the employee took three weeks to die of his injuries, which dulled some emotions. Second, the supervisor was extremely highly respected and so many people went to bat for him. Third, the supervisor was off-site on the day of the accident. However, all supervisory personnel in that production area lost their pay increments that year.

Highplant 2: Bill and the motor control center

Bill was terminated but was allowed his retirement benefits. As is standard for terminations, he was forbidden from going back to the area to pick up his tools or to say good-

² While these quotations are reconstructed from notes, the interviewee has reviewed them.
bye to his work mates of over 30 years. He was denied a retirement party. Reportedly, he felt extremely humiliated and denigrated by the whole affair. Given that management could have allowed him to retire “properly”, strategic choices were clearly involved here. Well placed interviewees believe that four layers of supervision were also punished for the accident with reduced performance ratings and pay increments.

Consistent with the argument that sense making is partially strategic, none of the systemic issues described above were addressed, even though they were surfaced by the investigating committee and could easily be important, albeit in a different form, when managing other risks. For instance, is it appropriate to allow a mechanic to work six straight weeks, often on nights (though not in Bill’s case), doing dangerous work? How was the ‘trap’ set? That is, why were the safety systems on the MCC deliberately over-ridden? Can the level of confusion be reduced around large tagging operations? Is it possible to manage the protective gear so it isn’t so uncomfortable? Put in more technical terms, the organization managed to surface, and ignore, a number of important propositions. Presumably management decided (at some conscious or unconscious level) that these propositions accounted for weak links in the causal chain.

I tested these ideas with a key decision maker. Of the termination decision, he said:

I know there are other strategies, but this strategy works. I didn’t select from a basket of strategies. The company has said that this is the strategy to use. I didn’t think about alternate strategies, especially in a case as flagrant as this. If the degree of deviation is less, there are other strategies. ... Also, I sensed the plant could use a demonstration of playing out the strategy to help themselves.

He went on to add:

However, it is very important to emphasize that it was my decision to terminate him. My bosses have a lot of interest. It was very clear what their expectations were, but it was my decision. ... We had had lots of discussion as a management team over the previous year in which we had laid out our expectations for behavior. This flagrantly violated our expectations.

I subsequently asked why he didn’t address the systemic issues as well. “Obviously I didn’t do both. I don’t have an answer to the question. It never occurred to me.” I asked whether there had been a legal motivation. He said that there may be a legal risk, but that had never occurred to him either.3

Another way we can see the strategic nature of the decision is by examining opinions up the hierarchy. About half of Bill’s co-workers thought management was justified in sacking him. Some felt he had walked into a trap (the MCC open and switched on) and so had suffered enough while not really being at fault. Others understood the company’s perspective that he had grossly violated procedures. However, even they wondered openly if he was sacked for getting injured rather than for violating procedures. Confidence in the decision increased with hierarchical level and distance from the people involved. One supervisor argued initially that Bill should not be sacked since he had a very long and unblemished record. With 30 years of service, he was considered one of the best, most conscientious, and hardest working

3 Bill did not sue, and legally had a very weak "wrongful discharge" case.
electricians on the site. He spent a lot of time training young electricians, and was often called for difficult jobs. He had never had an injury and had never had a disciplinary letter put on his file. The manager eventually supported his superiors. That manager's boss supported the termination decision but felt they should wait until Bill was out of the hospital and ready to come back to work. The next level manager supported the decision more strongly still, but spent his time answering the phone calls from corporate headquarters which asked why Bill hadn't been terminated yet, and generally shielding his report from corporate pressure.

Bill's accident in comparative context

Since Widesite had not had an accident of this severity recently, I asked people how different elements of Bill's accident would have been managed there. For example, I asked process operators how electricians reinstate MCCs, what they would do if they saw someone doing it wrong, and asked managers what would happen if someone was caught doing it wrong. I also asked how the accident would have been handled at Widesite.

There are key technical and procedural differences between the two sites.\(^4\) Notwithstanding, the operators at Wideplant told me that the electricians they observed always wore appropriate gear, used fuse pullers, and checked the voltage. However, the operators are often much less senior and do not feel they are in a position to 'know' how the electrician is meant to do the job. They generally would not stop an electrician who was violating the procedures.

Widesite would have terminated the electrician also, irrespective of whether he was hurt. Knowingly violating a key procedure would have been sufficient in an organization where everyone is (1) empowered to change procedures they disagree with and (2) bound to abide by existing procedures until a change is made. However, Widesite had already dealt with some of the systemic causes. For example, it is extremely rare for anyone to work nights or weekends on shutdowns which will take more than seven days; they have a much simpler lockout and tagout procedure than Highplant; and a lot more work goes into safety procedures to ensure the logic of the procedure is derived from the risk rather than a need for administrative

\(^4\) Wideplant has 220 V and 550 V systems, but not 480 V systems. The 550 volt systems have fuses too large for pullers, so the electricians use their hands and special gloves as well as a face mask and special clothing. For low voltage (220 V) systems, they don't, but it is not required. At Wideplant, in accordance with a national standard, the newer MCCs are designed so you can see the pins are physically disconnected. On those boxes where they can't see the pins, they always check the voltage.

The Widesite procedure would not require the electrician to lock the switch. In fact, it wasn't clear that it was required at Highsite until after the accident, but Bill was still blamed for not doing so. At Widesite the lock on the switch is reserved to protect people working on the motor controlled by the MCC. This locks the door closed, so it is physically impossible to lock out the system to change the fuses. [A difference in national standards]. Wideplant electricians don't feel any need to lock out fuse boxes they are working on because they are standing in front of it and can see that it is switched off. Many Highsite electricians made the same assumption before the accident.
uniformity.\textsuperscript{5}

We cannot know if they would have examined structural factors as well as punishing the victim. I asked a couple of managers and they immediately wondered why he violated procedures and if there was a training deficiency. Also, the different incident investigation procedure would lead them to address systemic issues. Notwithstanding, we can't know what would happen in reality. Tim's accident suggests they would address systemic issues; Danny's suggests they wouldn't.

\textit{Wideplant 1: Tim and the grating}

Unlike the Highplant case, neither of the Wideplant accidents was framed dichotomously by management, though both were framed dichotomously by the union. In Tim's case, Graham, Graham's boss, and the investigation committee categorized the accident in terms of a set of concentric rings emanating from the victim. Innermost was Tim. The next layer out involved the immediate task he was meant to do. Further out still were the elements that created that task the way it was -- the engineering, the actions of other workers, and so forth. Outermost were all the things the organization cannot control but has to manage -- the weather, corporate demands to reduce overtime, problems with raw materials supplies, and so forth -- all the things Graham's boss brought up in his speech. Given this categorization, it follows that if an accident occurs, participants have to consider the possibility of a systemic failure of the management system. If there is a systemic failure, management cannot hold people fully accountable for their actions, and may well make that failure worse if it attempts to.\textsuperscript{6} Therefore, although they are more proximate than the weather, they are less important.

It appears that there are four contributors to the conclusion that there was a systemic problem. All are clearly inter-related and derived from management's human resources strategy. First, the idea of the concentric categories of causation is virtually isomorphic to the notion of a 'circle of influence' discussed by Covey (1989). As we saw in chapter 13, Covey was one of the plant's two management gurus. Covey argues (without the accompanying 12 steps) that there are things we cannot change and things we can. Those we can change are inside our circle of influence. Managers should actively manage the things within the circle to take best advantage of those outside in the pursuit of their objectives (cf. Child 1972; Pfeffer and Salancik 1978).

Second, a couple of weeks before the accident, two well respected production operators ended the morning meeting with a very strong and emotional expression of concern about the management of the area. They felt that there was so much emphasis going into point rotation...

\textsuperscript{5} For example, the corporation ruled recently that all people in high fire risk areas must wear flame proof clothing. The fabric is extremely uncomfortable in very hot or cold weather. At Highplant, area management ruled all three of the production areas are high risk, even though there are no explosive fuels in one of them and the second only has a minor fire risk. At Wideplant, on the other hand, flame proof clothing is only required in one of the three areas.

\textsuperscript{6} Punishing people would be expected to depress morale further and therefore make people more distracted and less attentive.
and secondary skills that management was losing control of the process as a whole. "If we don’t
do something about it," they predicted, "there will be an accident." It is important to note
three structural factors developed through the previous chapters which make this possible.
First, Wideplant employees did not fear recrimination for publicly criticizing management.
Second, they were at the morning meeting and felt they had a voice to say what was concerning
them. Third, they had a higher sense of ownership for the production process and outcomes.

Third, the formal procedure for conducting the investigation did not require the
participants to find a "root cause". Rather, it asked them to identify three classes of causes:
failures of individual action, failure of systems, and sources of uncontrolled energy into the
system. This led people to look for more systemic causes for the accidents. Covey’s ideas
influenced the author of the procedure. Finally, Graham’s boss made a very strong and
powerful suggestion on the Monday after the accident as to what he thought was important.
Given the hierarchy, it would have been foolish for Graham to ignore this completely.

The union representative was extremely ineffective in an attempt to argue for an
alternate cause. Since management is very careful to maintain good relations with the union,
we cannot simply reject this as a power issue. The representative presented two arguments. The
first was to critique the way the investigation was carried out. It did not comply with the
strict requirements of the investigation procedure and the law. This argument had some weight
because the investigation leader was clearly under-prepared in these respects. In terms of the
argument of the previous chapter, he was trying to influence the outcome by influencing the
process by which sense making occurred.

The representative also criticized the analysis. Here, the argument was framed in
terms of a distinction between agency (management) and structure (the rest of the plant), as is
the case with the law. However, the representative was singularly unsuccessful. There
appeared to be two reasons for this. First, raising the procedural issues at the start of the
investigation made everyone extremely defensive. Second, because the critique was cast in
terms of different categories to those of the participants, there was no way for the two stories to
be reconciled. So, the arguments were rejected outright.

**Wideplant 2: Danny and the steam vent**

The failure to develop any substantive findings can be traced to the fact that the
investigation devolved into a fight between the union representative, one of the managers, and
the engineer responsible for the systems in the building. The representative felt that the
interim risk should have been managed better, but articulated it as an attack on management
for not warning Danny of the problem, the company’s standards for installing a three-way
switch, and the engineer for not fixing it sooner. In turn, the engineer became very defensive and
a manager who was also defensive made the mistake of asking the union why it hadn’t
identified the problem during the last union health and safety audit (just after a long
discussion of the highly contextual nature of the problem. (cf. Cebon 1993). This made the
atmosphere even more charged. Because of the charged atmosphere, the investigation leader
didn’t work to incorporate the union’s concerns, which several people in the meeting thought
were valid (over coffee afterwards).
Conclusion

In this chapter, I have done the following. First, I have applied the model developed in chapter 14 to show the way in which differing perspectives on the accident investigations can be understood in terms of different image schemas and categories of images, different proposition schemas and propositions, different tightness of coupling implied by a proposition, or different processes for determining the cause of the accidents.

In so doing, I have demonstrated that people in the organizations did not dispute what events had occurred. However, they imparted dramatically different meanings on them. The 'true' cause which emerged was a synthesis of those meanings which was derived from workplace politics.

In the next chapter I will demonstrate that for three of the accidents, the sense making process, which was nominally about an isolated technical problem, had far-reaching ramifications for the organizations.
18. The impacts of politicized sense-making

From chapter 16, it should be clear that there are a number of deep barriers to change and a number of pre-conditions which have to be met before change can occur. An effective change process must create those pre-conditions and overcome those barriers. In particular, it must allow contradictions between peoples' assumptions to emerge and be dealt with. This chapter will examine the organizational repercussions of three of the incidents discussed in chapter 17: Bill's accident with the motor control center and Mike's accident with the steam hose at Highplant, and Tim's accident with the steam grating at Wideplant. While the accidents clearly had local impacts -- Bill was fired; Mike was punished; Tim was neither -- the focus will be on the effect of the management strategy on both the organizations' capacities for change and on the change process itself.

There are two ways to read this chapter. The first is to see it as an elaboration of two of the barriers touched on in chapter 16. In particular, it demonstrates the way that attribution errors and formal rationality -- two of the major differences between the plants -- are inhibitors of change. The second is to see the two sites' experience as a type of thought experiment. We can imagine easily that either accident could have occurred at either site. And, given the desire, and an institutional environment that permitted it, management at either site could have pursued either strategy in the investigation. Therefore, we can imagine either site inheriting the products of either sense making exercise. When viewed from this perspective, we can see the way that the politics of sense making drives the change process. Put this way, this chapter illustrates the way that the sense making process for the two accidents sent the two organizations off on a change trajecory -- albeit a continuation of the trajectory they were already on -- and committed a huge amount of organizational resources to maintenance of that trajectory. For convenience, the chapter is written in terms of the second perspective. However, the reader should keep the first interpretation in mind.

Highplant

We will see in this section that, in the main, management's action at Highplant served to reduce the possibilities for meaningful change. Not only did it reinforce the status quo, but it also raised the barriers to change. This case illustrates two important points. First, Highplant management, by trying to enforce the idea of individual accountability, appeared to undermine its own legitimacy. That is, it couldn't find a way to impress upon the production employees the importance of taking individual responsibility for workplace safety outcomes and maintaining a feeling of mutual purpose. Second, and following directly from that, the case illustrates that some changes are much harder to make than others. If Widesite management were in a similar position, and felt that employees were not being responsible enough, and decided it wanted to hold careless people accountable, it may well have induced similar responses in the employees, and set back its own change effort.1

1 In fact, the site manager at another team-based Transitech site near Wideplant had just this problem at the time of the study.
From the analysis of Bill's accident (chapter 17), and the preceding chapters, it should be clear that management was trying to project two messages: that people should be careful and that they should make sure they follow procedures. There is nothing particularly insidious about these messages. Therefore, it is a surprise that morale plummeted. The operators attributed the low morale to three causes: the punishment of Mike, the sacking of Bill, and the punishment of the operator and the mechanics from another plant on Highsite, described in chapter 10, when an operator found a tagging error which the mechanics had not picked up. I was surprised, given the huge number of alternative sources for morale problems (e.g. plant reliability problems and a depressed market for the product).

The operators interpreted Mike's punishment as meaning that they were expected to be infallible, and would be punished if they were not. However, they did not feel they could be infallible. This was reflected in one of my first conversations in that phase of the field work. When I explained the thrust of the study to one of the operators, he immediately asked whether I thought all accidents could be avoided. I chose to not have an opinion. Some weeks later I asked one of his colleagues the same question and he said, "No, I believe in the concept of human frailty."

There were two messages from the sanctioning of the operator and the mechanics. As noted in chapter 10, the operators and mechanics were very concerned about the high complexity of the new tagging procedure. They felt that it was not possible for them to implement it safely and reliably, especially under time pressures. They felt their pleas about the difficulty of implementation were ignored. Instead, it appeared to them that they would be held responsible, even if they tried their best. In this respect, the message was similar to that from Mike's accident. The second message came from the way events had unfolded. If management had conducted an audit and found the tagging error, that would have been one thing. However, the error was found a different way. The day operator, being responsible, checked the job when he took it over. He then 'did the right thing' and reported it to his supervisor. Instead of the crew being congratulated for his responsible behavior, his colleagues were punished. The operators made some fairly obvious inferences from this. First, if they find problems, supervision doesn't want to know about them. Second, they cannot trust supervision to be their ally when dealing with problems and their resolution. That is, they and supervision are not working together, they are in opposition. Finally, real problems are best managed informally, irrespective of what the procedure says.

The message from Bill's sacking was different again. As we saw above, Bill was a model employee and was well liked across hierarchical levels and across the site. While the operators were split on whether or not he should have been sacked, they objected universally to the way it was done. They felt the company could have allowed him to retire in a dignified manner which reflected more than 30 years of good service. Instead, they felt he was humiliated. The message people drew from this was that if they get hurt badly enough, they will be sacked, irrespective of their prior work record.

As noted above, the overarching measure of an effective change process is the ability to identify and deal with conflicting assumptions between parties in the organization. Just in discussing these accidents, I have identified three. First, the operators assumed that they had the right to some sort of job security if they had put in many years of good service. Management, on the other hand, assumed that it had the right to make job security conditional on satisfactory performance, irrespective of the number of years of service. Second, while

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2 The role of the pension plan is important here. The pension plan had a formula which,
management assumed that procedures with more safeguards were automatically more safe (cf. Perrow 1984), the operators, on the basis of their experience, believed that they weren’t always. Third, the operators assumed that supervision wouldn’t hesitate to ask them to do dangerous jobs if there were production pressures. In contrast, the supervisors assumed that they never would do so consciously, and if they did so unintentionally, the operators would bring it up and they could work it out (see also chapter 10). Undoubtedly there were many more conflicting assumptions.

While these conflicts in assumptions were being surfaced regularly, and I, by talking to people on both sides of the organization, had no trouble seeing them, there was no safe context in which they could be discussed. This is best illustrated by the case with the operator and the two mechanics above, where the result of the operator taking a concern to a supervisor was to have his colleagues punished. We also saw it in the training session described in chapter 10, where the training mechanic talked about concerns with the tagging procedure and was met with defensiveness by a plant leader, and no legitimation of the concerns.

In addition to the overarching condition of having a process which allows conflicts between assumptions to be surfaced and discussed, we saw a number of subsidiary conditions which facilitate this. First, we saw in chapter 10 that the work organization at Highplant tended to encourage attribution errors. In particular, we saw that virtually all the operators believed that supervision would pressure them to work unsafely to get a job done quickly at times of high demand. However, discussions with the supervision indicated that this was much rarer than the operators claimed. Highplant’s sense-making choices increased the tendency to attribution errors. We saw in chapter 10 that the likelihood of attribution errors increases when people have low power, low trust in the people with power, or low control over their work. The operators had three concerns: that they would be punished if they make a mistake and get hurt, that they will be punished if they show any of their problems to management, and that they will be punished irrespective of their duration of service. The three concerns reflect those three conditions. Furthermore, the tendency to make attribution errors exacerbated the situation. These concerns became much more palpable when people thought it was likely that they could be put involuntarily in a risky situation. It would also tend to accentuate the concerns, even though management was trying to give out a different message. It should be clear how this tendency toward making attribution errors reduces the organization’s capacity for change.

Second, in chapter 11 we saw that there was a tendency toward formal rationality on the site, that is a tendency to do what is required irrespective of whether it is sensible. I exemplified this with the supervisor who insisted on obtaining a definitive ruling on whether some tank inspections fell within the realm of the revised combined space entry procedure, even though it didn’t change the job in any material way. Again, the management of these accidents depending on age and years of service, determined when people could retire with their benefits. Therefore, there was a certain date which on which the production workers were focused. The operators felt encouraged by these accidents to retire at the earliest possible date.

3 We also saw that they supervisors did not believe that they were pressuring the operators. Rather they believed the operators simply didn’t understand the work. Furthermore, the supervisors appeared to make the same attribution errors as the operators, and believed that their bosses pressured them to get the operators to do unsafe jobs.
would tend to reinforce this tendency. One of the few ways in which people thought they could protect themselves was by following procedures religiously and avoiding making any decisions.

It is through these two tendencies -- the tendency to increase attribution errors and the tendency to increase a reliance on formal rationality -- that we can see the importance of bringing psychological variables into our understanding of organizational politics. Because of the attribution errors, the operators (and supervisors) on the site interpreted management's ambitions as being much less reasonable than they really were. Because of the tendency toward formal rationality, it would be much harder for management to get people to became engaged at all, and therefore capable of changing.

A third pre-condition for change is that people have to feel psychologically secure in the face of the change. Because of the attribution problems, the Highplant operators felt significantly less secure than they needed to. Management started with some laudable objectives, namely to get people to obey procedures and behave responsibly. However, by the time these made their way to the production areas, people were feeling very insecure. For example, people simply didn't see Bill's termination in terms of failure to follow procedures. Instead, they saw it in terms of management capriciousness. Therefore, instead of fearing termination for not following procedures, they feared termination for getting hurt.

We saw also, in chapter 16 that change is facilitated in six other ways:

* by reinforcing desired behaviors both rhetorically and behaviorally,

* allowing for variations between people in their rate of understanding the change,

* encouraging opinion leaders to see the change as legitimate,

* encouraging opinion leaders to see that management has their best interest at heart,

* allowing people to see the new approach in use in their organization, and

* creating a context where people can see when the new principle applies, and when the old one does.

From the discussion above, it should be clear that management undermined the possibility for all of these.

**Wideplant**

At Wideplant, in contrast, management's strategy in interpreting Tim's accident with the grate led to the event being enacted as a crisis. As a result, it became a trigger for punctuated change (Tushman and Romanelli 1985; Gersick 1991; Sastry 1995). This had two effects. First, it reduced the size of a number of barriers to change. Second, it forced management to increase its commitment to change in a number of key ways. First, management had to commit a significant amount of resources (management time and worker time) to a process for resolving workplace issues. Second, management took a risk in that it became obligated to resolving the issues that came out of the process without knowing in advance what they would
be -- whereas before it could control them by suppressing them. Third, to keep the barriers low, management would now have to both manage the broad discussion and implement the solutions which came out of the process. These could all be expensive.

Shortly after Tim's accident, Graham called a meeting of all the engineers and supervisors in area 'A'. He opened the meeting by presenting the "safety pyramid" which shows the ratio of deaths to major injuries to minor injuries (see also chapter 14). However, he extended this further by asking rhetorically what causes the minor injuries. Taking a cue from his boss's comments at the managers' meeting, he answered that injuries are caused by distractions and other uncontrolled events both inside and outside the organization. Over the next couple of hours, the group created a list of activities which were causing problems and distractions. Their list was similar to the manager's (see chapter 17), but included a number of extras, including some capital projects currently being implemented and aspects of the work system, such as conflicts over day point rotations and secondary skills.

This group met twice more over the next week and refined its understanding. Eventually they reached two conclusions. First, the current system of work organization was flawed and needed to be reviewed and redesigned. Second, for political reasons, they were the wrong group for the task. Rather, to be effective, the organization must be redesigned by a group of hourly employees assisted by some supervision. Therefore, Graham created a new group of four controllers (a fifth was added six months later), one mechanic, one engineer, the personnel facilitator, and himself. The four controllers and the mechanic were invited very carefully. All invitees accepted. There was one per crew, and Graham made sure these included opinion leaders from each of the three demographic groups and the two controllers who had raised concerns initially at the morning meeting (see chapter 10). One of these was the controller who had worked the unauthorized overtime during the blizzard (chapter 16). (For these meetings, the aggrieved controller received his overtime as compensation.)

From the outset, Graham made the group feel important. Rather than having them meet in the plant conference room, Graham booked the leather-upholstered site conference room. He provided ample coffee, orange juice, and doughnuts -- the company's universal symbol of prestige. The first meeting was opened by the business manager who put his seal of approval on the process and gave it legitimacy. However, he also fulfilled another important function, which was to say "what are the givens." This is important since people understood that their power was bounded by management. Graham's initial concern was that the controllers wouldn't treat it as a serious exercise. Instead, they would think the committee was just there to placate the controllers. The manager, therefore, had to give them permission to feel empowered. However, the manager also performed a third function, namely to put some boundaries on the exercise. In particular, he emphasized that while management still has control over the broad strategic direction, everything within that boundary was negotiable.

By the end of the field work, a year after the accident, the group had met ten times. I attended two meetings and interviewed Graham about the rest. It was now a permanent committee of the plant and would continue to meet monthly indefinitely. The group's first meeting was a replication of the initial meeting which Graham had with the facilitators and engineers. The team developed a list of stressors in the plant. "The good news", Graham told me, "was that there were no great surprises." The management group had been aware of the major problems in the area. Graham then gently steered the group toward a strategy for thinking about the problem, namely how to think about problems of work organization.

However, Graham had no "insurance policy" against the whole process falling flat. He was vulnerable in two ways: to people who just wanted to just "deal with the problems" rather than the underlying issues, and to the committee making demands on which he couldn't deliver. On the latter front, he protected himself initially by emphasizing to the committee
that any changes which affected other groups on the site had to be approved by those other groups.

Over the first few months, the group set about educating itself about the logic of the work organization. The system they used was employed very commonly throughout the site for many learning activities. They would obtain old documents, such as the "principles about performance, behavior, and business" which were written by the group which designed the organization. They would then discuss each principle in turn, deciding on its relevance for their organization and making comments on it. This is interesting because of the way it structured the learning task. Even people who didn't understand the gestalt of the organizational model could still participate competently if the original document were written well. All they needed to do was respond to each principle independently. Those who did understand it could respond to the list as a whole and see if they want to add or subtract items. This approach had two advantages. First, it was one way of getting people with different levels of commitment to the organizational reform process to participate in a debate. Second, by breaking the organizational design (or whatever else is being discussed) into 20 parts, the level of sophistication of the discussion could be quite high, even if it wasn't highly integrated.

After a few months, the group hit a few obvious targets and made some 'progress'. In particular, they reduced the number of 'p int' positions from four to three and eliminated one of the facilitator positions (this was essentially forced by an early retirement program designed to appease the corporate parent during its massive retrenchment of middle managers in the U.S.). This had the effect of reducing the proportion of their time that people would spend on days, but of increasing their workload when on days. Second, they changed from three member crews with two people working a day schedule to cover vacations, sickness, and extra days off to four-member self-relieving crews. Finally, they reduced the period that people spent on days from six months to three. The mechanic on the team objected to this last change, saying that it took three months to train the planning point to do the job properly, and that the shops would never get good maintenance scheduling if people rotated every three months. However, the team over-ruled him and he stopped coming to the meetings.

Slowly, however, the process started to unravel. As the group moved from more abstract principles to the details of the work organization, some specific conflicts started to emerge. In particular, the group started to fight about the rotation system and secondary skills. In essence, two members of the team didn't want to go to days at all, and kept coming up with reasons why they shouldn't have to. Furthermore, they didn't tend to listen to Graham's answers as to how they didn't really have the choice. Site management was mandating it.

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4 This allowed people to take some of their extra days off on night shifts, instead of day shifts only.

5 In theory, the actual duration of rotation shouldn't matter much. If people spend three months on days, they will spend another three months about a year later, instead of six months every two years. When I asked the mechanic about this, he explained that the system was so precarious that there was a good chance that a given controller would have changed points by the next time he or she went to days.

6 On my last visit to the plant, Graham started to understand that this was an issue, and was making overtures to the mechanic that they should talk. The mechanic seemed to be avoiding the discussion, but it wasn't completely clear to me.
Graham attempted an intervention, where he showed videotapes of Covey’s principles (e.g. changing only the things you can influence, seeking joint-gains solutions). This seemed to work for a while, but still members of the team focused on their gripes about these two topics. Eventually, Graham stood up in front of the group and said that site management had observed that day rotations are the best technique they have for encouraging people to grow. If the area wanted to stop going to days, they would have to persuade site management that they had developed a better technique. In the meantime, they had to start doing things that impress senior management so they could make a case some time in the future. That seemed to work, in that he reframed the problem from one of never being able to stop day rotations, to not being able to stop them for the time-being, and needing to build a case to stop them.

In the mean time, a number of different team rotation designs were circulating through the plant. There were two basic designs. The first had one member from each crew going to days or secondary skills every rotation period, as was the case at the time. The second design added a fifth crew, which would go to days every fifth rotation period. The second approach appeared to be superior. The crews wouldn’t be broken up and reconstituted the whole time; the people going to days wouldn’t have to form themselves as a crew but would know how to work together from the start; the rotations would be much easier to plan; and people would know a long time ahead what their rotation schedule would be. However, the crews rejected this universally. The problem was that it would take the area out of synch with the rest of the site, which constituted an important reference group. Since people car-pooled and socialized across the site, they didn’t want to switch.

Eventually, one of the controllers on the committee developed a way around this problem. However, by that time, both he, and the five-crew concept had become the scapegoat for peoples’ antagonism. At that time, the controller was working on days. One morning when he walked into the morning meeting, the panel operator made a derogatory comment which indicated that the day point had signed on to management’s side. The controller was clearly upset. In fact, he had been one of my best informants during earlier visits, and we got on well. However, on this last visit, when he was catching all the grief, he was clearly very depressed and refused to talk to me. I don’t know whether this was more a sign of his frustration with his inability to get people to buy into the five-crew concept than feeling a need to be seen to be distancing himself from me.

In the end, Graham put his foot down. He decided that people’s main concern was not the specifics of the rotations, but the level of uncertainty the system was engendering (cf. Thompson 1967). If people could predict when they would rotate to days, they would complain less. The problem, he concluded, was that they had changed the system three times in the prior year. Furthermore, people were swapping with each other at their convenience, making it impossible to keep the system coherent. He instructed his personnel facilitator to come up with a rotation design, which he presented to the area saying that there would be no swapping and that they would try his plan for 15 months. At that time, he would open it up for discussion again. To my surprise, everyone was really happy about this move on his part. It seems that the lack of certainty and the apparent lack of decisiveness by management were the major sources of concern after all. However, that was also in the last week of the data gathering, so anything could have happened since!

It turns out that there aren’t enough degrees of freedom in the system to be able to support people swapping with each other without there being a high probability of it creating a clash of some sort later on.
In addition to the rotations, the other issue that people were up in arms about was 'secondary skills'. They had started the secondary skills program by eliminating two mechanic's positions and creating two controller's positions. Therefore, the positions for the secondary skills program were owned by the mechanical organization. The controllers fell into two groups: farmers and the rest. The farmers could fix anything and didn't feel they had anything to gain from the mechanical skills program. They wanted to work in the laboratory or with computers, or other more interesting tasks. As for the others, in the first few rotations, the mechanics had asked the controllers to do fairly boring jobs. As a result, people became antagonistic to the idea. This antagonism lingered. In addition, a number of people, both trainees and senior controllers, complained that their core skills declined during the rotations. They were spending so much time doing other things, that they were losing their edge as operators.

In the meantime, the area 'B-C' mechanics had a number of concerns about the program. In particular, it changed their responsibilities. When their first batch of fully qualified controllers (as opposed to trainees) came onto a mechanical rotation, the mechanics were suddenly training -- and taking responsibility for the safety of -- people who were being paid more than they were (because of the shift premium). This provided an object onto which they could attach their concerns. The mechanical supervisor was still refusing to give up the positions, saying he would be short of mechanics. Eventually, Graham decided he had enough power to force the issue. At a meeting of the business management (the business manager, the production coordinators, the mechanical supervisor, and the head of engineering) he won control over the positions again. This freed up the system so production management could expand the secondary skills program.

If we were to go back through this extended example, we would see that, in the main, Graham managed to create a process which met most of the criteria for effective change laid out in the previous chapters. I won't bore the reader by doing so. However, he still managed to lose control of the process. The controllers were antagonistic to two centerpieces of the change model, the secondary skills and the rotation to days for point work, and believed that Graham had the power to stop them both. They didn't understand that these things were well beyond his control, and they had to solve the problems by working within the constraints management had set. In order to placate them a little, he allowed them to reduce the rotation period from six months to three. However, this angered the mechanics. Furthermore, the mechanics were antagonistic to the secondary skills because it eroded their skill base and took up their time (this was more of a problem in area B-C than in area A). The controllers, on the other hand, thought it was a waste of time. As the group got further and further embroiled in trying to work through the issues, the various solutions started to acquire labels and therefore started to be accepted and rejected on the basis of their proponents, the order in which they were proposed, and so forth. Furthermore, the number of potential solutions started to proliferate. In the end, there was no possibility of consensus on one solution, just on a range of acceptable solutions. Furthermore, different controllers were starting to get "bruised" by the battles over the proposals. Graham selected one solution in the range, clearly a sub-optimal one, and imposed it on the group.

In sum, the process was not easy and, in the end, the resolution of many issues came with an intervention from Graham. Graham had to take a leap of faith and have tremendous trust in some of his controllers. He had to be constantly aware of the boundaries he was placing on the action, and the controller who bought in most, caught grief from those who bought in least. If the process had been a failure, he would have set back the change process.

While it was fairly predictable that the process would become most conflictual over the day rotations and secondary skills, it took several months for the exact conflicts to emerge clearly enough to do anything about them. In the end, the conflicts emerged in unpredictable
places and the solutions which emerged were highly dependent on the way the problems themselves came to light.  

\[8\] For example, if Graham had pushed for the entire business unit going to a five-crew system, he probably would have faced very little opposition. This would have solved similar problems for the other production supervisors. Similarly, if the chief proponent of the five-crew system had pushed a four-crew system instead, they may well have gone to a five-crew system.
19. Conclusions

This dissertation has answered two relatively straightforward questions about the organization and management of two chemical plants. First, it asked about the similarities and differences in work organization, and how they translated into differences in performance. Second, it asked about the processes by which change was occurring, or not occurring, in the two plants. To answer these questions, I constructed a typology of 12 types of tasks in the plants, based on whether they were routine or exceptional, production oriented or learning oriented, and whether the activity involved initiation, sense-making, problem-solving, or implementation, and compared the management of these tasks.

The first third of the dissertation discussed the technology and the activities associated with “compound” production. In addition to describing the similarities and differences between the two sites, it also had to address a fairly central question to organization theory. In particular, given a tightly coupled technical process, and a long literature on the relationship between technology and organization, how can it be that the two plants have such divergent work organizations? I analyzed this from the perspective of how people in the plants perceived time, as well as examining the tasks people performed. I found that, for routine production activities, the work and its organization was essentially identical. An operator, mechanic, or engineer from one plant could go easily to the other and, after about a day of familiarization, work productively. Given that the vast majority of the work in the plants (on a time-averaged basis) was routine production, this observation is non-trivial. The routine work and the technology were tightly coupled. Where the coupling was looser — such as with the rotation periods between jobs on a crew — differences emerged. The real differences, however, were in the way the plants dealt with exceptions and learning, whose management was respectively only loosely coupled to, and virtually decoupled from, the technology.

In the process of working through these issues, the first part of the dissertation provided a detailed “thick” description of the organizations and the work. The big surprise to me was that the differences were not terribly large at all. Although the “gestalt” of the two plants was radically different, most of the work was routine, and was carried out in approximately the same way. Furthermore, while I have emphasized differences in the organization and conduct of the other activities, the range of variation within the two sites was probably about the same size as the differences between them. This left me wondering why the performance differential should be so pronounced, and I concluded that the technology (and particularly the way they chose to run it) was so tightly coupled that anything which added or subtracted slack to or from the organizational system would affect performance. Therefore, the devil really would be “in the details” of the differences in work organization.

The differences were in three domains, which I have labelled as skills, stance, and flexibility. There were clear skill differences between the sites, and these translated into both a lower tendency to generate exceptions and better problem-solving skills at Wideplant. I aggregated power, trust, and control into a macro construct which I called “stance” because there was a tremendous amount of interaction between them, they were clearly linked by the histories and strategies at the site, and most important, most of the differences in behavior were within the realm of acceptable behavior at either site. As I analyzed the effect of stance on outcomes, the big surprise was the way the intersection of politics and cognition was much more important than either variable singly. This manifest itself two ways: as attribution errors about the motives of others, and as formal rationality. Both created major barriers to
exception management and organizational change. Attribution errors meant that people perceived the organization to be more political than it really was. Formal rationality enabled people to create a disconnect between what they thought and the way they acted.

In retrospect, given a slack-starved system, it is no surprise that flexibility should be vital to improving performance and facilitating change. However, I had not thought of that going into the study. In order to make that observation, I had to develop some of my prior work to develop a fairly novel theory of flexibility in organizations.

The final third of the dissertation discussed organizational change. It is the start of an attempt to explain why small changes in organizations are so difficult when people understand what changes are desired (i.e. there is no cognitive mystery to be solved), and to describe the process by which change occurs. First, I described the sites’ change histories. We see that both organizations started in about the same places, and that Wideplant was able to move forward through time, while Highplant’s change efforts were constantly frustrated. Consistent with the punctuated change literature, Wideplant’s change efforts began with a discontinuous event (a long strike). Then, I argued that there are two types of changes, political ones and cognitive ones, and given the interaction of politics and cognition in the second third of the dissertation, laid out a framework for a theory of change that can deal with politics, cognition, and their interaction.

I then started to fill in that framework by describing the strategies management used as it tried to achieve change, and the barriers it encountered from the people in the plants, as it tried to execute those strategies. There are two interesting things about the strategies. First, given that Transitech tends to employ people for their entire working life, it was surprising the extent to which management at Wideplant was able to successfully replace people who were socialized to the old organization with people who were fully supportive of the new one. This was done by careful recruiting following a set of retirements, selective recruiting from within the site for the prototype plants for the new work organization, and by carefully moving people out of the plants into less strategic locations on the plant site. Also of interest was the way that these selection-based strategies served to create prototypes both of organizations and of people within the organization on whom the people who were expected to change could model themselves.

There were a surprising number of barriers to change. First, by examining what it means for people to adopt a “rule” and the problems that creates, we see why it is that attempts to implement “best practices” in organizations have been fraught with difficulties. Put simply, the chances of a fundamental change, rather than a symbolic implementation through formal rationality, are very low. When I examined what it took for people to implement a “principle” I saw that, in addition to basic cognitive barriers, there were barriers created by diffusion processes within the organization, reference group effects, and the legitimacy of the change agent (exacerbated by attribution errors), among others. Furthermore, another set of oft-neglected barriers arose because of a need for ongoing production in the organization. In particular, because the plants had to keep running and many people had not yet bought into the changes, management had to constantly switch between the new organization (for the converts) and the old one (for the laggards). Finally, because the organization was open with changing demands coming from corporate management, local management appeared to the workers to be extremely inconsistent in what it wanted and unable to make any firm promises in return for changes.

The final two chapters examined sense-making around a series of accidents which served as punctuating events, and the changes that resulted. In essence I found that through the strategic construction of categories, management managed to steer the findings of the incident investigations to develop findings which reinforced its human relations policy. At Highplant,
this led to change, but not the change management wanted. At Wideplant, in one of the two cases, this opened up the whole organizational design for renegotiation. However, by the end of the study it was not clear how successful that renegotiation had been. People became so upset about the uncertainty it created that management eventually had to intervene and impose a solution.

Further research

This dissertation suggests a number of areas for further research. I will simply elaborate on four key ones.

First, the analysis of flexibility suggests the possibility of opening up research on flexibility in organizations to many more domains than has been the case historically. In particular, this study suggests two further studies. First, research is needed to see if this is a sufficient model to describe all types of flexibility in organizations. If not, the model needs to either be extended to incorporate those other domains, or the nature of the domains to which it does not apply need to be specified clearly. Second, if the model proves sufficient, research is needed to explore the role of flexibility in organizational performance.

Second, it appears that a lot of work on organizational behavior and change needs to be rethought in terms of the interaction of politics and cognition, not just in terms of traditional political and cognitive variables. This is particularly true when we see that the traditional cognitive variables used to explain social category formation and their relationships -- metaphor and metonymy -- need to be supplemented by such organizational variables as routinization and power relations.

Third, there is a need for a much clearer specification of what tight and loose coupling mean, as terms, and what the implications of that clearer specification are for our understanding of causation in organizations. In particular, the terms are generally used to describe entire systems, or the relationship between the core and the periphery of the organization. However, the idea of taking the notion of coupling down to the level of the relationship of individual organizational elements, as I have done here, seems to be worthwhile.

Finally, the analysis of sense-making in the four accidents begs important questions about causal models in the social sciences. In particular, we need to ask very critically about the role of coupling, and historically-contingent categorization in the causal stories we use to describe the social world.

Implications for Transitech

First, and principally, the problems of attribution error and formal rationality can be expected in any organization. However, in Transitech, with its strongly control-oriented culture, these problems were acute. These made the organization much more political in virtually everyone's mind that it actually was, and undermined trust. They also prevented people from actively thinking about the problems they faced. Problems relating to these were observed in all aspects of the organization, including new capital design, new strategy
formation, change efforts, and ongoing operations. Reducing these problems corporate-wide might well significantly alter corporate performance.

Second, the history of change in many Transitech plants, and particularly in Highplant, appears to be a mix of implementing rules (which led to formal rationality) and wholesale movement to principle based management (which led to failure of the organization). If, instead of many attempts at rapid change over time, any change effort in a large corporation has to be seen as a 15-year effort, with a variety of strategies being used, and many strategies being used at once. In particular, it appears that the introduction of principle-based management works best if the domain to which it applies is clearly circumscribed by rules for behavior (but those rules are always renegotiable away from the production process). While overall design ideas can be developed centrally, the appropriate design for a given organization will be highly dependent on the local technology, market, and site and must evolve locally.

Third, while people talk a lot about organizational structures, many of the changes that need to be made can occur effectively within existing structural arrangements. The attitudes (or stance) of powerful people is probably more important than the actual arrangements. However, changes in stance by management will take a long time before they are reflected in changes in the stance of less powerful employees.

Fourth, the existence of flexibility in the organization appears to have a tremendous impact on its ability to perform either in a changing market, or during a change effort.

Fifth, the analysis of accident causation in chapter 7 suggests that every accident has at least two causes. Therefore, "root cause analysis" is a theoretically flawed concept.

Finally, there are at least two substantive issues that have been left open and need to be resolved by the corporation. If neither formal nor practical rationality can provide the panacea for effective operations, the corporation needs to work to develop an understanding of how to use the two simultaneously to obtain the benefits, rather than the liabilities, of both. Similarly, the analysis of the accidents in chapters 17 and 18 suggests that management's hands were tied. At both sites, the aftermath of the investigation process created a tremendous amount of upheaval in the organizations. Furthermore, Highplant management's attempt to hold the victim accountable led to tremendous discontent on the site. A similar thing happened at another Transitech site near Widesite. This suggests that Transitech management needs to think through the implications of its safety management approaches in a broader management context.
20. References


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