IMPLEMENTING RADICAL CHANGE: GRADUAL VERSUS RAPID PACE

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ABSTRACT

This paper explores the question of how radical changes are implemented in organizations. The literature either does not directly address this issue or implies that radical change can only be implemented rapidly. In fact, to speak of the *gradual* implementation of *radical* change may at first glance appear paradoxical: how can radical change be implemented slowly? We examine the assumptions underlying various notions of radical change, and suggest that it may be useful for both conceptual and managerial reasons to distinguish, at least analytically, between the *nature* or degree of organizational change (radical or incremental) and the *pace* or speed of its implementation (rapid or gradual). Drawing on the findings of a field study that investigated the implementation of radical change in systems development, we show that the gradual implementation of radical change may not only be feasible, but also effective in some situations. Specifically, we identify characteristics of the organizational context and the technological innovation that can indicate the conditions under which gradual implementation of radical changes may be appropriate.

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Implementing Radical Change: Gradual Versus Rapid Pace

There is considerable attention being paid today—both in the research and practitioner literatures—to the importance of organizational change around the introduction of new technology. Calls to reinvent the corporation, reengineer business processes, and redesign work flows have become the fashionable response to the so-called information technology paradox. Hammer's (1990) by now well-known dictum, "Don't Automate—Obliterate," accurately captures the general sentiment—to gain real benefits from investment in information technology, managers must accomplish radical change in their organizations.

Implementing radical change in organizations is no mean feat, as several studies comparing radical and incremental change have demonstrated (Dewar and Dutton, 1986; Ettlie, Bridges and O'Keefe, 1984; Orlikowski, 1993; Tushman and Romanelli, 1985). In contrast to incremental change, where established structures, processes, and knowledge are extended and augmented, radical change replaces the status quo with a new order of things and as a result may create serious disruptions in structures, processes, operations, knowledge, and morale. Jobs are altered and eliminated, skills are gained and lost, information flow is redefined and rerouted, processes are transformed and created, responsibilities are transferred, and power bases are undermined. Managing such disruptions becomes critical to the experiences and outcomes associated with radical organizational change.

This paper explores the question of how radical changes are implemented in organizations. The literature either does not directly address this issue or implies that radical change can only be implemented rapidly. In fact, to speak of the *gradual* implementation of *radical* change may at first glance appear paradoxical: how can radical change be implemented slowly? We became intrigued by this question during a research study of the implementation of CASE (Computer-Aided Software Engineering) tools in systems development. Orlikowski (1993) and Fichman and Kemerer (1993) have shown that a

number of software development innovations such as CASE tools, development methodologies, and programming languages can represent radical change in the work, knowledge, and organization of systems development. The organization we were studying was clearly implementing a radical change in software development, represented by the adoption of the IE methodology and IEF CASE tools. Yet, the implementation of these radical changes appeared to be proceeding somewhat gradually. This apparent paradox prompted us to examine the relationship between the nature or degree of change and the pace or speed of its implementation, and in particular to confront the oft-taken-for-granted notion that radical change can only be implemented quickly. In contrast to the expectation that the slow implementation of radical change necessarily means reducing it to a series of incremental changes, our research findings suggest that under certain conditions the gradual implementation of radical change may be not only feasible, but also effective.

Before considering the research study which generated these implications, we believe it is instructive to examine some of the assumptions that underlie our understandings and notions of radical change. In particular, an examination of both business and academic writings on the topic suggests that there are multiple and different meanings as well as uses of the term. Our research findings have made us realize that it is useful for both conceptual and managerial reasons to distinguish, at least analytically, between the *nature* or degree of change (radical or incremental) and the *pace* or speed of its implementation (rapid or gradual). That is, it is possible to characterize an organizational change in terms of two dimensions, as represented by the two questions: how big is the change? [nature] and how quickly is the change accomplished? [pace]. In this we follow Gersick's (1991) recommendation to differentiate between the processes of change (e.g., pace of change) and their outcomes (e.g., nature of change). As our brief review of the literature will indicate, such a distinction is not always made. We believe that disentangling these two dimensions of change can be particularly valuable in helping us think about and deal with the implementation of radical change.

Literature Focusing on the Nature of Change Only

The technological innovation literature makes a strong distinction between incremental and radical types of technological innovation (Dewar and Dutton, 1986; Ettlie, Bridges and O'Keefe, 1984; Pennings, 1988; Tushman and Romanelli, 1985), so as to indicate "the degree of change they create in the existing practice of the adopting organization" (Damanpour, 1988:549). Incremental change amounts to an extension of the status quo, that is, adjustments or refinements in current products, processes, relationships, knowledge, and norms. Such changes represent "minor improvements or simple adjustments in current technology" (Dewar and Dutton, 1986:1423). Radical change replaces the status quo, requiring a shift to fundamentally different products, processes, relationships, knowledge, and norms. In using the notions of radical and incremental change, these innovation researchers do not refer to and appear to make no assumptions about the pace with which the change is accomplished.

Literature Focusing on the Pace of Change Only

While some researchers focus specifically on the nature of change, others focus only on the pace of change, without making any reference to the degree of change being implemented. For example, in his research on organizational innovations, Van de Ven (1993:286) advocates rapid implementation because the trial period of an innovation is brief: "After the honeymoon period, innovations terminate at disproportionately higher rates, in proportion to the time required for their implementation." Similarly, Kanter (1983) argues that because slow implementation of change may allow resistance among workers to accumulate, decisive and expeditious action on the part of management is required. In the same vein but taking an opposing stance, other researchers argue that a more gradual pace of implementing change may be more effective in general. For example, Hage and Aiken (1970:106) suggest that the longer the implementation period, the longer the period of trial and error, thus "the greater the chances of the new program achieving its intended

objectives." Likewise, Rogers (1983:364) notes that "too-rapid implementation of the innovation...can lead to disastrous results" because when the introduction process is rushed, problems that later interfere with effective use of the technology may be ignored. While these researchers differ on whether they advocate a slow or fast pace of implementation, they are similar to the extent that none of them specify the type or nature of change to which their recommendations apply.

Literature Combining the Nature of Change and the Pace of Change

In contrast to those researchers who only focus on one or the other of the two dimensions of change (nature or pace), a number of commentators in both the research and business communities see these dimensions as either inseparable or as interdependent. On the former side are researchers in organizational strategy who assume that the dimensions of nature and pace of change are not independent. That is, they make assumptions about both the nature of change and the speed with which change is accomplished when they use terms such as incremental (or evolutionary), radical (or revolutionary), and quantum change (Miller, 1982; Miller and Friesen, 1980; 1982). For example, Quinn (1980, 1982) describes "logical incrementalism" as a way of constructing business strategy that combines a "step by step" process [pace] with an "incremental" effect [nature].

While not going so far as to consider nature and pace of change as inseparable, many writers treat these dimensions as highly interdependent. That is, they assume that only particular combinations of these two dimensions are feasible. For example, Hammer (1990; Hammer and Champy, 1993) has argued that a rapid implementation is the only feasible way of accomplishing radical change. He notes that "Reengineering cannot be planned meticulously and accomplished in small and cautious steps. It's an all-or-nothing proposition with an uncertain result" (1990:104-105). Tushman, Newman and Romanelli (1986:39) observe that resistance to "fundamental change is natural. If frame-breaking [radical] change is implemented slowly, then individuals have a greater opportunity to undermine the

changes and organizational inertia works to further stifle fundamental change." Likewise, in the area of expert systems, Sviokla (1992:30) notes that transformation technologies (his term for radical changes) "need swift, concentrated action to make change. The benefits of speed have been documented copiously."

With respect to incremental changes, some researchers have suggested that a gradual pace of implementation is warranted. For example, Tyre and Orlikowski (1993, 1994) have shown that the introduction of new production technologies may be more effectively accomplished if executed through a series of phases. In their research they found that the implementation and adaptation of technologies in organizations were not accomplished in a single concentrated implementation period. Rather, these occurred episodically over a long period of time. Comparing these research findings to practices in Japanese firms, Tyre and Orlikowski (1993) conclude that some incremental changes to technologies and work practices may be implemented more effectively if managed in a phased or episodic manner.

Implications for Managing Change

Despite these various discussions of implementing change, there remains little guidance to help change managers choose an appropriate pace for the radical change they wish to accomplish. As we saw above, many of the discussions of *pace* of implementation in the literature do not explicitly discuss the *nature* of change. For those authors advocating rapid or gradual implementation, it is often unclear whether their recommendations apply to radical or incremental innovations—or both. Those who are specific about the nature of change when advising a particular implementation pace imply a strict coupling of rapid implementation with radical change (Hammer, 1990; Sviokla, 1992; Tushman, Newman and Romanelli, 1986), and phased implementation with incremental change (Tyre and Orlikowski, 1993, 1994). Yet, there is some empirical evidence that the implementation of radical change does not have to be done rapidly. Based on a study of 41 firms implementing flexible manufacturing systems, Ettlie (1986) found that a gradual pace of change was

among the most frequently cited factors contributing to the successful implementation of radical technological changes. He argues that: "It is wise to take a strategic approach to phased adoption and implementation for these major [radical]...changes in systems" (1986:80). In a similar vein, Greiner (1992), has suggested that a gradual approach toward organizational restructuring is associated with more favorable change outcomes.

The implication of these various discussions and recommendations is thus ambiguous, and the question—which pace of implementation is more effective in the context of radical change—has not been systematically addressed. The conditions that indicate a rapid versus a gradual pace of implementing radical change remain unspecified. That is the issue we explore in this paper.

Below we examine the details of one organization's experience in implementing a radical change, paying close attention to the nature of the changes being realized and the timing with which various changes were accomplished. We then interpret the findings in the context of the rapid versus gradual pace debate, and attempt to outline some of the organizational and technological conditions that appear to facilitate either rapid or gradual implementations of radical change. While our study examines the radical change that was associated with the introduction of new technology (CASE tools) in systems development, we believe that the issue of implementation pace applies more generally to other organizational changes as well. The broader question of whether radical change associated with new information technologies is better implemented swiftly or more cautiously is one that transcends the particular details of the change being attempted.

RESEARCH METHODOLOGY

Our field study investigated the implementation of a set of integrated CASE tools in a large chemical products company located in the midwest—hereafter called MidCo. We were interested in understanding the systems development changes associated with these CASE tools. Data were collected through on-site interviews executed during two separate visits

four months apart, follow-up telephone interviews, and a review of available documentation. The on-site interviews followed a semi-structured interview protocol, and lasted about an hour in length. Thirty-five respondents participated in our study, representing several different divisions at MidCo (both business and IS) and several different organization levels (staff, department managers, and division managers). Table 1 shows the distribution of respondents across vertical and functional lines. The documentation we examined included general information about the organization, as well as specific materials related to the evaluation and implementation of CASE tools.

Table 1: List of Interview Respondents by Position and Function

Level in Organization	IS	Business	Total
Sr. Executive (e.g., Vice President, Division Manager)	1	3	4
Middle Manager (e.g., Department Head)	6	3	9
Staff (e.g., Project Manager, Analyst)	16	6	22
Total	23	12	35

Data analysis employed qualitative techniques (Glaser and Strauss, 1967; Miles and Huberman, 1994). We searched our interview transcripts and available documentation for themes, using a technique of open coding that allowed us to detect patterns in the data which were consistent across respondents, or which showed divergence across different types of respondents. In the case of inconsistency or incompleteness, we probed for clarification and confirmation during our second site visit and through telephone interviews.

MidCo is a multi-national chemical products company with revenues of $1.4 billion and over 5,000 employees worldwide in 1991. MidCo competes in several different market niches and is the market share leader in its various product segments. MidCo's profitability is driven by its relative superiority in chemical technology, and this is understood to be

critically dependent on R&D effort and excellence. This understanding is reflected in the prominence afforded R&D within the company. Nearly all executives occupying the CEO and COO offices have come from positions in R&D, and investment in research is heavily supported (5.1% of revenues in 1991). One executive highlighted the critical position of R&D by noting that "Research drives the vision here—everything else is in the dust." The managerial philosophy expressed by senior managers suggests a willingness to make current investments in order to reap future gains. Respondents frequently mentioned MidCo as a "[chemical] technology leader" and the firm had adopted a firm-wide quality management program in 1987. This quality management program, based on the approach of Deming (1962), was initiated to strengthen and sustain the company's strong performance, rather than to resolve any particular problem areas. The Deming approach was selected because it was seen to be consistent with MidCo's scientific and engineering culture. A long-term goal stated by one of the executives was to achieve "a flatter, empowered organization," with teamwork and ready access to information across departmental lines.

RESEARCH RESULTS

Context for the Changes in Systems Development

MidCo's corporate IS division was centralized with approximately ninety full-time employees, organized into six departments each headed by a department manager. Three of the departments were application development groups which developed information systems for specific business divisions, and three were technical support groups. The application development groups were organized around the major divisions of the corporation: R&D, Logistics, and an "umbrella group" of traditional business functions.[1]

The IS managers and staff referred to the user departments they supported as "customers" rather than as users. The mission of IS was described by the IS director as follows:

> To be a value-added business partner, to help our customers do their jobs—but as a partnership, not a service to them.

Although the IS division did not directly charge the business divisions for its services, there was nonetheless a sense of ownership by each business division for the systems requested by them. The business divisions also assumed an informal claim over the IS staff within the specific application development group that supported them.

IS was both similar to and different from the business. Employee turnover in IS was very low, as in the rest of the company. The commitment to quality, innovation, and empowerment, so prevalent in the rest of the company, also pervaded IS. For example, there was a shared belief that the role of IS was to "empower users to do their jobs with available information" as one senior IS manager put it. The IS division differed from the other business divisions in that it had a larger proportion of younger members and women employees. About half of the IS employees were women, including five of six IS department managers. An IS manager observed:

> We are risk takers. We are pushy. We are very young age-wise. We have as many female as male employees. Everyone gets an equal chance in the IS organization.

Background to the Changes in Systems Development

Prior to implementing CASE tools, MidCo was using the *Method/1* systems development methodology purchased from Arthur Andersen. The Method/1 methodology provides software development guidelines based on a set of structured, process-oriented design principles (cf. Yourdon and Constantine, 1978). In 1987, the IS division created a Data Administration group, which began using James Martin's (1982, 1990) data-centered Information Engineering (IE) approach to guide their systems planning efforts. At this time, there were no automated tools available to support the IE methodology, and manual methods were used to perform the various IE analyses. This period coincided with the adoption by senior MidCo management of Deming's quality management program, and the

acquisition of the IE methodology was seen as compatible with this broader quality initiative. The deployment of IE however, did not extend beyond the Data Administration Group, and the rest of the IS division continued to follow the Method/1 systems development methodology.

In 1988, the IS division began experimenting with two early CASE tools. These were not integrated CASE tools, but stand alone tools that each supported a single step of the system development life cycle. One was an upper-CASE tool, called *Information Engineering Workbench* (IEW), which was based on the IE methodology, while the other was a lower-CASE tool, *Telon,* which allowed IS analysts to generate application code. Both of these stand-alone tools received limited use within the IS division, their lack of integration with the rest of the development life-cycle proving to be a significant drawback.

Table 2: MidCo's Selection Criteria for Choosing a CASE Tool

(Source: MidCo Corporation, IEF Evaluation Project, December 1989, page 2.3)

- The need for complete life cycle support.
- The support of a data-driven methodology.
- The need for a fully integrated set of tools to support the life cycle. Rekeying of data is to be minimized.
- The availability of the toolset on the PC, in particular the analysis, design, and at least some testing.
- The enforcement of a particular methodology, eliminating the potential of varying from a given approach.
- The support of multiple platforms.

In 1988, the Data Administration group decided to evaluate software tools to structure their data management activities. They first reviewed and rejected a group of data dictionary tools, and then shifted attention to a class of integrated-CASE software tools which were

being introduced to the market at that time. At this point the Data Administration group realized the potential of integrated tools for supporting all of IS development, and derived a set of product evaluation criteria that reflected their new understanding of the value of integrated CASE tools to MidCo (see Table 2). An Evaluation Committee consisting of IS managers and senior analysts was formed in 1989 to conduct a detailed review of three major integrated CASE tools.[2] Based on the evaluation criteria, the committee members selected IEF[3] (*Information Engineering Facility* from Texas Instruments) and a hand-picked project team was assembled to perform a pilot project. After a short but intensive pilot study, the Evaluation Committee recommended that MidCo purchase IEF and proceed with full-scale implementation of both IE and IEF across all IS division activities. In a formal report in December 1989, the Evaluation Committee outlined the IS division's goals for full implementation of IE and IEF, and issued a set of detailed implementation recommendations. In their report, the committee emphasized how IE reflected and reinforced the quality principles practiced at MidCo:

> IE and quality management have many things in common and are, in fact, mutually supportive of one another. Both are founded on teamwork and a scientific approach based on data....Implementing the IE approach...would reinforce the quality management effort and further strengthen the quality of systems development at MidCo.

During 1990, each of the IS division's three application development groups initiated projects using IE and IEF. Several consultants from Texas Instruments were on-site during this first year to provide expertise, advice, and support with the implementation. Training on IEF was conducted in small groups, with separate courses for each of the seven steps of the IEF methodology (see Table 3). MidCo tried to have its employees trained as close as possible to when they needed a specific skill, an approach the respondents referred to as "just-in-time training."[4]

At the time of our second site visit (in late 1991), IEF was being used on eight concurrent projects by the three application development groups. While use of IEF was not mandatory, it was "highly encouraged" by senior IS managers. These managers allowed the

different application development groups to use IE and IEF in various and customized ways, permitting them to deviate from the guidelines recommended by both the IE methodology and the IEF tool. For example, in contrast to the recommended use of IEF which calls for the derivation of a top-down enterprise-wide information model or Information Strategy Plan (ISP), senior IS managers had decided not to require a top-down ISP for the corporation at the outset. Similarly, most IS project managers did not insist that individual business divisions create their own ISP before they embarked on the design and development of a specific business system. Instead, each business division was permitted leeway to conduct the ISP or to proceed directly to the next IE phase—Business Area Analysis (BAA). The expectation was that divisions would return to complete an ISP after having gained experience with using IE and IEF on single applications.

Table 3: Description of the Stages of Information Engineering

(Source: Texas Instruments, 1990, *Introduction to Information Engineering,* pp. 3-4)

Information Strategy Planning (ISP) - Planners gain a broad view of the information needs of the business. From this information, they create a blueprint for the future and subdivide the blueprint into smaller segments.

Business Area Analysis (BAA) - Analysts examine a particular segment of the business called a business area. They develop a detailed, conceptual model of this business area, based on its information needs.

Business System Design (BSD) - Designers detail a *business system* within a particular business area. They consider how the user will interact with the business system, without concerning themselves with the target computing environment.

Technical Design (TD) - Designers tailor the result of BSD to a target computing environment. They consider the hardware environment, operating system, teleprocessing monitor and database management system.

Construction - Developers generate all the executable components of a system. These include programs, databases, job control statements, screen formats, and transaction definitions. These pieces enable an application system to run in the selected target environment.

Transition - Developers install a newly constructed application system in a production environment. This phased installation may involve replacing existing systems or portions of systems.

Production - The business realizes the full benefit of the application system. Its execution satisfies specific business needs identified during the ISP.

The Nature of the Changes in Systems Development

MidCo's primary goal for investing in CASE tools was to adopt and implement the principles of data-centered design, which IE embodied and IEF enabled. This shift from a structured, process-centered systems development approach to a data-centered one can be characterized as a radical change in systems development (Fichman and Kemerer, 1992; Orlikowski, 1993). As might be expected, this radical innovation involved a number of significant changes to the work of systems development. One IS manager commented on this innovation by contrasting it to others she had experienced:

> The change resulting from IE is the methodology, not just the automation... People didn't see a large change with code generators, but with integrated-CASE—it changes the way you work.

Another IS manager noted that,

> ... when you talk about bringing about a major change such as CASE tools, you are really changing the way people work.

We found evidence for three specific types of changes that were associated with the radical innovation implemented by MidCo—changes in IS analysts' skills, changes in the role of users on project teams, and changes in coordination across multiple project teams.

Many respondents commented that use of the CASE tools had changed their role from application programmers to business analysts. Because the new IE-based systems development process was more oriented toward business issues, a greater proportion of the tasks performed during systems development focused on business analysis compared to more traditional methodologies, including the previously-used Method/1. In addition, respondents noted that the skills and knowledge they needed to develop systems with IEF no longer covered areas such as programming, hardware details, and operating system specifics. For example, respondents no longer needed their detailed knowledge of traditional programming languages (e.g., COBOL) and database design techniques to be productive. Their use of IEF facilitated a greater focus on the business and more conceptual aspects of systems, decreasing their prior preoccupation with technical matters.

Changes in roles and skills also extended to the user groups, because use of IE and IEF had increased the level of user involvement on all system development teams. A new IS policy had been implemented as part of the deployment of IE and IEF in the IS division; it stipulated that a number of business users had to be significantly involved during the analysis phases of a project, and that they had to take responsibility for project deliverables. This expanded and more participatory role afforded the users was described by one IS analyst as:

> Now they [users] are an integral part of the development effort. Their input into the development must be constant and ongoing... they must be dedicated full time.

Such increased attention to users represented a significant departure from prior systems development efforts, and coincided with and reflected the increased emphasis being placed on empowerment and learning in the rest of the organization.

Respondents also noted that projects using IE and IEF began to have a particularly inter-disciplinary and cross-functional character. There was a greater emphasis on integrating and coordinating project planning across several business divisions during the early stages of BAA. These integrating efforts typically occurred in Joint Application Development (JAD) sessions, a mechanism recommended by the IE methodology, where business requirements are identified by IS and user staff.[7] Another new coordinating mechanism was the creation of the *information architect* role, filled full-time by an analyst from Data Administration who assumed responsibility for coordinating the data models of all projects, ensuring consistency across them, minimizing data redundancy, and assuring data quality.

The Pace of Implementing Changes in Systems Development

The overall change in MidCo's systems development process (the shift from a process-oriented to a data-oriented systems design approach) involved a series of changes, beginning with the initial implementation of IE on a limited basis within Data Administration, and then its diffusion along with IEF to the rest of the IS division. As is evident from Table 4,

Table 4: Implementation of Radical Process Changes in MidCo

BACKGROUND	DATE
Implementation and Use of *Method/1* structured systems development methodology	1985
Adoption of Quality Management Program	1987
PROCESS CHANGE	**DATE**
Formation of Data Administration Group	1987
Adoption and implementation of *IE* in Data Administration Group	1987
Adoption and limited use of *IEW* in Data Administration Group	1988
Adoption and limited use of *Telon* in IS Division	1988
Pilot study of IEF	1989
Adoption of *IE* and *IEF* by whole IS Division	1990
Use of *IE* and *IEF* in "Umbrella" Division: First use of IEF on a project First use of ISP	 1990 1990
Use of *IE* and *IEF* in R&D Division: First use of IEF on a project First use of ISP	 1990 (none scheduled)
Use of *IE* and *IEF* in Logistics Division: First use of IEF on a project First use of ISP	 1991 1992 (scheduled)

(shaded cells represent background events to the process changes)

this shift took several years and was not absorbed all at once. The IS director stated, and many other respondents concurred, that "the move to CASE was an evolution, rather than a revolution." Another IS manager similarly noted,

> This [the change to IE and IEF] requires tremendous amounts of patience. It's a long slow process...I knew from day one that it was going to be right. It just takes a long time.

MidCo's gradual pace of implementing radical change significantly influenced the general

experience of the change by the organization and its employees. For some respondents, particularly those employees who had already been using IE for up to two years before IEF was adopted, the implementation of the IEF tool was seen as a continuation of a change already begun and therefore they were willing and able to embrace it relatively easily.

For the other IS employees, who had not been previously exposed to IE, the implementation experience was moderated by the control they perceived over when and how they would assimilate the IE methodology and IEF tool. Not required to assimilate both changes immediately and in full, these employees were able to more gradually accommodate the changes. Because IS managers had provided an opportunity for employees to adapt the implementation of IE and IEF to their own schedules, the changes were not perceived as overwhelming or threatening—a common response to radical changes in the workplace.

The general experience of the radical changes within MidCo appeared to be surprisingly uneventful. A striking finding was the apparent absence of resistance by both IS employees and users. While our interviews probed for evidence of resistance, disruption, frustration, and unanticipated problems associated with the changes, we found no such data. In fact, the reactions of our respondents was generally very positive. One IS manager who described the CASE implementation as "far more successful than we expected," noted that most of the project teams were eager to try out the IE methodology and IEF tool. As she put it, "people are clamoring for it—people want it."

The one concern we detected from a few respondents was some skepticism. However, even this was accompanied by a willingness to stay open-minded, and to wait and see if IE and IEF delivered the promised benefits. One senior business manager commented that "we are taking the benefits on a leap of faith right now," but indicated that he expected to observe benefits in the near future. He noted that other managers in his division had adopted a "wait-and-see attitude" toward the changes. This reaction reflects the gradual implementation strategy adopted by MidCo in that it had permitted each business division to implement the changes at their own pace rather than forcing them all to accept and

implement the changes immediately. The decision not to conduct an enterprise-wide or top-down ISP for the whole business allowed each business division to control its own implementation of IE and IEF, deciding when and whether to conduct an ISP and when to focus on specific application areas so as to produce tangible system products. This decision appears to have been appropriate for the MidCo organizational context, as a senior executive explained that business managers would not be willing to wait for the completion of a top-down ISP data model before requesting specific application systems.

Based on their first full year of experience using IE and IEF in the three application development groups, respondents described their enthusiasm for continuing to develop systems using the new approach. In addition, due to the greater emphasis on business planning and analysis—which IE and IEF enable—some IS managers indicated that further organizational changes were now possible. For example, several managers described that some functions currently residing in the central IS group would be "dispersed to the business divisions over the next five years." This general decentralization of IS to the business divisions, enabled by the systems development changes of IE and IEF, had already begun at the time of our second site visit. One IS application group—that supporting the prominent and powerful R&D division—had been reorganized so that it was physically located within the R&D division and reported to R&D management. IS managers describing this transfer noted that IE and IEF had facilitated this change, because they allowed a tighter alignment of IS and business interests, and promoted a closer working relationship between IS and the R&D division.

DISCUSSION

Based on MidCo's experiences with implementing CASE tools, it appears that they had implemented a radical change in their system development process, and that they had done so gradually. The pace of implementation we observed more closely resembled the episodic pattern identified by Tyre and Orlikowski (1994) in that the change was implemented in

phases, rather than the rapid and revolutionary pattern advocated by Hammer (1990) and others. But in contrast to Tyre and Orlikowski's phases which involved only incremental changes, each of MidCo's phases represented a radical change in systems development when compared to the existing practice of developing systems. Further, it appears that MidCo's radical change had proceeded relatively smoothly, without the turbulence typically associated with radical organizational changes. In particular, the implementation of IE and IEF did not generate active opposition from employees in either the IS or the business divisions. On the contrary, these changes were enthusiastically received and appeared to be causing minimal disruption in operations and morale.

The MidCo study suggests—in contrast to recommendations advocating rapid implementation of radical change—that there may be conditions where a gradual or episodic pace of implementing radical change may be effective. Our findings emphasize the importance of not only distinguishing the pace of implementing change from the nature of the change, but of understanding how they relate. Where the nature of a change refers to *what* magnitude of change is intended or realized (radical versus incremental), the pace of implementing change refers to *how* the change is being implemented, that is, the speed with which it is introduced (rapid versus gradual). From this perspective, the nature and pace of change are seen as conceptually distinct dimensions of change, that become related in the implementation of any particular change. How these are to be related in any particular change project is thus a choice that should be made by the change agents involved.

The distinction between the nature of change and pace of implementing change essentially decouples the two dimensions, allowing us to imagine the possibility of implementing radical (and incremental) changes rapidly or gradually. Table 5 shows the separate dimensions of nature and pace of change, and uses this as a structure for mapping this and other research which investigates the implementation of organizational and technological change along these dimensions. In this table, we can see that both radical and

Table 5

The Nature and the Pace of Change: Two Dimensions of Research on Organizational Change

Nature of Change	PACE OF CHANGE: Gradual	PACE OF CHANGE: Rapid
Radical	Ettlie, 1986 Gallivan, Hofman & Orlikowski, 1994	Liker, 1987 Orlikowski, 1993 Seeger, Lorsch & Gibson, 1974
Incremental	Mackay, 1990 Orlikowski, 1993 Tyre & Orlikowski, 1994	Kraut, Dumais & Koch, 1989 Orlikowski, 1992

incremental changes may be implemented gradually or rapidly. This begs the question: if a rapid or gradual pace may be used to implement radical change, what are the conditions under which a certain pace is suggested? Based on our study of MidCo and an examination of the literature, we suggest that there are two key elements that may facilitate or inhibit a gradual pace of implementation: characteristics of the organizational context and characteristics of the technological innovation. We examine each in turn.

Characteristics of the Organizational Context

With respect to the organizational context, MidCo had certain structural and cultural characteristics that appeared to contribute to the effectiveness of implementing radical

changes gradually. First, the company had a tradition of valuing investments in technology that might not have immediate payoffs. Expectations in this research-oriented firm thus reflected a willingness to invest time and resources to achieve long-term benefits. Second, the corporate philosophy reflected a commitment to quality, empowerment, and learning. As an executive observed, "we are in the learning business." The cultural norms and work practices within IS similarly reflected these sentiments, as is evident in the focus on teamwork, user involvement, and empowering the business. Third, there was no immediate crisis in systems development to compel MidCo to rush the implementation of IE and IEF. The motivation to adopt radical changes in the absence of serious problems parallels the motivation behind the company's adoption of Deming's quality management program—a sense that things could be better. Fourth, the company was doing well financially and so had sufficient slack resources to implement change slowly. It could thus afford to adopt a more measured pace and to spend time on training, consulting, experimentation, and feedback. Clearly these characteristics will not be present in the organizational context surrounding all new technology adoptions, and hence the experiences at MidCo do not represent a universal strategy for achieving radical change; however they do point to some possible ones.

In this light, it is instructive to compare MidCo's experience with that of another firm implementing IE and IEF, as described by Orlikowski (1993) in her examination of a firm called PCC. In particular, the experiences and outcomes around the radical change experienced by MidCo differ substantially from those experienced by PCC. Differences in the organizational conditions around PCC's change are worth recounting as they serve as a useful contrast to those we detected at MidCo.

Like MidCo, PCC introduced IE and IEF into its systems development activities, and like MidCo, this represented a radical change in PCC's process of systems development. However, the pace of implementation adopted by PCC managers was rapid, unlike that at MidCo. At PCC, both IE and IEF were introduced simultaneously, thus IS and business personnel had to learn and assimilate the data modeling concepts of the new methodology

at the same time as they were learning to use IEF. PCC also initiated IE and IEF by enforcing the execution of a top-down ISP for the entire business. This represented an enormous effort for both IS and the business, because the ISP relied on design principles that were unfamiliar to most of the participants, particularly the business users. Finally, the IS division instituted a new policy of only developing systems in the sequence recommended by the resulting top-down ISP. Thus, PCC's IS division changed the rules by which it delivered service to the business divisions and it did so abruptly. Not surprisingly, these changes precipitated strong resistance from business managers and users, which threatened to undermine the entire change initiative. At MidCo, in contrast, the new rules for delivering systems services to business divisions were implemented gradually, with much less disruption.

This contrast between MidCo and PCC suggests that a significant benefit associated with a gradual implementation of radical change may be that it is often experienced as more palatable. This may significantly reduce the level of user resistance to the change. When combined with other aspects of the organizational context such as a nurturing and self-developing culture, a resource munificence, and an orientation to innovation and experimentation, these may add up to an effective set of conditions for implementing radical changes over a longer period of time.

Characteristics of the Technological Innovation

Prior research on the management of technological innovation suggests that characteristics of the innovation itself may also influence the pace of implementation, not just the context into which it is being introduced. One such characteristic is the extent to which a particular technological innovation can be subdivided into smaller components—a concept that has been variously labeled divisibility (Rogers, 1962; Leonard-Barton, 1988), trialability (Rogers, 1971), and reversibility (Walton, 1975). Leonard-Barton (1988) differentiates the concept of divisibility into two subconstructs—modularization and individualization. The

former allows for segmenting the innovation or the change program into discrete chunks, while the latter allows the innovation to be implemented into parts of the organization in sequence.

Examining the gradual implementation process at MidCo in terms of these concepts, we see that it was both modularized and individualized. Table 4 shows that different components of IE and IEF were implemented over time and the various divisions and project teams chose to use these as appropriate. Within each application development group, the adoption of IE and IEF represented radical innovations to software development, because when compared to the previous systems development approaches in use, they were "clear departures from existing practice" (Dewar and Dutton, 1986:1423). Each implementation phase was thus still a radical change, not an incremental one. The fact that one group preceded another in adopting the IEF tool for performing strategic systems planning did not render the change an incremental one, since it did not reduce the scope of the required change to a "minor improvement or simple adjustment in current technology" (Dewar and Dutton, 1986:1423). Hence, contrary to the possible interpretation that MidCo had simply achieved an overall radical change through a series of incremental changes, we believe that MidCo was adopting a series of radical changes through gradually implementing them into distinct work groups. The *radicalness* (Damanpour, 1988) of changes in developers' work processes, knowledge, and coordination efforts was not diminished by MidCo's phased implementation tactics which were facilitated by the innovation's divisibility. The strategy of decomposing a radical innovation into discrete phases for separate work groups (individualization) or into separate components (modularization) does not necessarily transform a radical change into a series of incremental ones.

Research suggests that the divisibility of an innovation increases the likelihood of more effective implementation for three reasons. First, as Rousseau (1989:43) notes, introducing changes "one by one...increases employee confidence in their abilities to learn and use new systems." Hence, the users are more willing to participate in the change since the stakes are

reduced and the costs to them are decreased.

Second, divisibility provides opportunities for experimenting with the innovation and making changes to it. As Leonard-Barton (1988:613) notes, "Divisibility is an important implementation characteristic because it allows trial of a new technology for the purposes of feedback and learning." For example, Tyre and Orlikowski (1993, 1994) show how discrete episodes of change—which they label "windows of opportunity—allowed users to accumulate particular problems or desired enhancements to their technology or work procedures until they were ready to make changes. Without this pacing of issues, users felt too overwhelmed and too busy to take the time to fix all their problems at once. Likewise, Leonard-Barton's (1988a) notion of cycles of mutual adaptation recognizes that when a technology is first introduced, misalignments always exist between the technology and the organization. Such misalignments cannot all be resolved up front, and it is only over time, through iterative cycles of change that the technology and the organization can be aligned with each other.

Third, users will be better able to assimilate the innovation, because they can implement it in a piecemeal fashion and hence can control the pace of the changes they experience. Leonard-Barton recommends that, where an innovation is modularizable, that sponsors and champions "allow user managers some control over the pace of change, by presenting the potential for implementation in phases, rather than all at once" (1988:626).

These notions of windows of opportunity, cycles of mutual adaptation, and controlled change suggest that significant benefits in learning, participation, and flexibility may be afforded by a gradual pace, whereas such benefits may be forfeited in the rush to implement rapidly. This clearly happened at MidCo, where the use of IE and IEF was encouraged but not enforced from the top, and where divisions were allowed to adopt this software development innovation at their own pace over a period of time rather than all at once.

With regard to the generality of the gradual approach to implementing radical change, we recognize that not all innovations may be divisible to the degree observed at MidCo. In

evaluating the various strategies involved in divisibility, however, it is useful to consider separately an innovation's modularization and its individualization. While not all radical innovations may be modularizable, since, in some cases, the new processes, knowledge, and structures are so interdependent that they must be implemented as a whole (e.g., the paradigm shift associated with a radically new scientific theory), many more innovations can be individualizable, that is, phased in into discrete work units or sites in sequence. Many authors have, in fact, advocated such an implementation strategy to allow an organization to learn from the implementation experiences of the early adopters of the radical change. For example, Opper and Fersko-Weiss (1992) recommend a staged implementation of new technology, using distinct phases of experimental and expanded pilot studies, where each pilot draws on the previous one's experiences. Other researchers have described the benefits of vicarious learning (Leonard-Barton, 1990:186) through which potential users of a new technology can acquire the *know-how* and *know-why* of earlier adopters—either within the same organization or externally (through product user groups).

Managerial Intentions

In this paper we have been considering the question of how to implement radical organizational change. Implicit in this question is the assumption that there is an intention by the stakeholders—usually managers—to accomplish radical change. Thus our focus is specifically on the question of how to implement intended radical change. While there are many instances where a series of small incremental changes can, when aggregated over an extended period of time, result in a radical change (e.g., species differentiation [Gould, 1989] and meteorology [Gleick, 1987]), these are examples of *unintended changes*. We certainly believe that unintended changes are inevitable whenever shifts occur in physical, biological, or social systems. And sometimes the accumulation of quantitative shifts may at some point transform an entity into a qualitatively different one (Ollman, 1971). However, in the context of trying to understand how to manage organizational change, we are

concerned with change that can be planned, guided, and controlled—that is, intended change. As a result, we have not, and cannot within the scope of this paper, consider the question—how to implement **unintended** radical change.

In the case of MidCo, managers of the IS division clearly had intentions for the *nature* of the change—wanting to radically change the way of developing systems and delivering service to their clients. Their intentions for the *pace* of implementation reflected an understanding of their organizational context. In particular, they realized that requiring radical changes to be implemented all at once would run against the grain of MidCo's long-standing participatory and learning-oriented culture. Hence, they encouraged the involvement of the divisions in realizing the intended radical changes by allowing them to design and control their own process for implementing and adopting the radical changes represented by the IE methodology and IE CASE tools.

While MidCo's managers utilized their company's favorable conditions for gradually implementing radical change, there certainly are conditions where pursuing such a gradual pace would be counterindicated. In particular, where a company or department is facing a crisis, whether an external competitive threat or an internal crisis of legitimation or production, managers' intentions are focused on survival, and hence they are likely to initiate a rapid implementation of radical change. Likewise, where a company or department has a track record of not being able to sustain a change process over an extended period of time, or where there is limited organizational capacity for change (Pettigrew, Ferlie and McKee, 1992), managers may believe it is prudent to implement as much change as is possible as quickly as possible. Under these conditions, managers' intentions for rapid implementation would seem appropriate given that the opportunity to change anything later may be lost as enthusiasm wanes, skepticism grows, resistance accumulates, resources are reallocated, and champions are reassigned.

CONCLUSION

The research we reported in this paper drew on a field study to analyze one implementation of a radical organizational change. We suggested that the pace of implementing change (rapid versus gradual) should be distinguished, at least conceptually, from the nature of change intended (radical versus incremental), and the two considered as separate choices facing change agents. Recognizing this distinction is particularly valuable as it affords researchers and practitioners a broader perspective from which to evaluate or manage change processes. It allows researchers to explain, for example, why two apparently similar technology implementations—the radical changes implemented in PCC and MidCo—resulted in two quite different experiences and outcomes. It allows practitioners to treat these two concepts as separate choices to consider when embarking on a change program. An examination of the particular organizational and technological conditions offers some guidance for deciding how a radical change would be more effectively implemented.

While our articulation of the concept of implementation pace extends understanding of organizational change, there are limits to the current research. It is based on a single field study, conducted at only two points in time, around a particular change, and the implementation process was acknowledged by our respondents as still in progress. Nevertheless, we believe that the findings of this research have some interesting implications for researchers and offer new ways of thinking for practitioners.

Despite the common wisdom that radical change can only be implemented rapidly, we suggest, on the contrary, that under certain conditions it may be implemented episodically. Based on an analysis of the implementation of CASE tools in one organization, we found that a gradual implementation pace was a useful strategy for achieving radical change in the software development process. While more research is clearly needed to examine this finding in other settings and with other technologies, we believe that this finding is insightful as it suggests that there is more than one way to accomplish radical change. We outlined a number of conditions: characteristics of the organizational context (such as a culture that

values continuous improvement, a strategy that invests over the long-term, an absence of crises, and sufficient slack resources), and characteristics of the technological innovation (such as divisibility) that may represent important indicators of the feasibility of a gradual implementation pace. While these organizational and technological conditions require further empirical exploration, they nevertheless can begin to guide change agents in fashioning an appropriate implementation strategy to accomplish intended radical change. We believe that the findings and argument presented above represent a useful starting framework for helping researchers and practitioners think about and evaluate the implementation of intended radical change around new technology in organizations.

ENDNOTES

1. The business functions included in the umbrella group are Finance, Sales, Marketing, and Human Resources. MidCo's three other IS departments handle technical IS functions—data administration, technical support and operations.

2. The three integrated CASE tools reviewed were Arthur Andersen's *Foundation*, Knowledgeware's *IEW* and Texas Instruments' *IEF*. The version of IEW available at that time was a new release with more functionality than the version MidCo had experimented with previously. Unlike its predecessor, the new release claimed to be integrated and capable of supporting the entire system development life cycle.

3. The IEF CASE tools from Texas Instruments consist of a set of integrated software routines for identifying business needs, designing, developing and maintaining computer information systems. IEF also includes a central repository of standard data definitions (or data dictionary). It is an integrated CASE technology, because it supports all the phases of IS development, and the work generated in one phase is used in later phases. IEF is strongly influenced by the IE methodology developed by James Martin (1990).

4. There was also an IEF overview course taught to MidCo's IS managers and many of the business division managers, in order to familiarize them with the new systems development process that would be used in the firm. In addition, some business users were also trained when they were designated to participate on a specific IS project.

5. The Joint Application Design (JAD) process involves assembling a broad range of representatives from user and IS groups, and collectively generating ideas, defining requirements, and negotiating the specifications for system design (Davidson, 1993).

REFERENCES

Damanpour, F. "Innovation Type, Radicalness, and the Adoption Process," *Communications Research,* 15, 1988, 545-567.

Davidson, E.J. "An Exploratory Study of Joint Application Design in Information Systems Delivery," *Proceedings of the 14th International Conference on Information Systems,* J.I. DeGross, R.P. Bostrom, and D. Robey (Eds.), Orlando FL, 1993, 271-285.

Deming, W.E. *Out of the Crisis.* New York: Pantheon Books, 1962.

Dewar, R.D., and Dutton, J.E. "The Adoption of Radical and Incremental Innovations: An Empirical Analysis," *Management Science,* 32, 1986, 1422-1433.

Ettlie, J.E. "Implementing Manufacturing Technology: Lessons from Experience," in D. Davis (Ed.), *Managing Technological Innovation,* San Francisco: Jossey-Bass, 1986, 72-103.

Ettlie, J.E., Bridges, W., and O'Keefe, R. "Organization Strategy and Structural Differences for Radical Versus Incremental Innovation," *Management Science,* 25, 1984, 682-695.

Fichman, R.G., and Kemerer, C.F. "Adoption of Software Engineering Process Innovations: The Case of Object Orientation," *Sloan Management Review,* Winter 1993, 34(2), 7-23.

Fichman, R.G., and Kemerer, C.F. "Object-Oriented and Conventional Analysis and Design Methodologies," *IEEE Computer,* October 1992, 22-39.

Gersick, C.J. "Revolutionary Change Theories: A Multilevel Exploration of the Punctuated Equilibrium Paradigm," *Academy of Management Review,* 1991, 16, 10-36.

Glaser, B., and Strauss, A. *The Discovery of Grounded Theory.* Chicago: Aldine, 1967.

Gleick, J. *Chaos: Making a New Science.* New York, Penguin Books, 1987.

Gould, S.J. "Punctuated Equilibrium in Fact and Theory," *Journal of Social Biological Structure,* 12, 1989, 117-136.

Greiner, L. "Resistance to Change During Restructuring," *Journal of Management Inquiry,* 1992, 1, 61-65.

Hage, J., and Aiken, M. *Social Change in Complex Organizations.* New York: Random House, 1970.

Hammer, M. "Reengineering Work: Don't Automate, Obliterate," *Harvard Business Review,* July-August, 1990, 68(4), 104-114.

Hammer, M., and Champy, J. *Reengineering the Corporation: A Manifesto for Business*

Revolution. New York: Harper Business Press, 1993.

Kanter, R.M. *The Change Masters: Innovation and Entrepreneurship in the American Corporation.* New York: Simon and Schuster, 1983.

Kraut, R.M., Dumais, S. and Koch, S. "Computerization, Productivity and Quality of Work-Life," *Communications of the ACM,* 32, 1989, 220-238.

Leonard-Barton, D. "Implementing New Production Technologies: Exercises in Corporate Learning," in M.A. von Glinow and S.A. Mohrman (Eds.), *Managing Complexity in High Technology Organizations*, New York, Oxford University Press, Chapter 9, 169-187.

Leonard-Barton, D. "Implementation Characteristics of Organizational Innovations: Limits and Opportunities for Management Strategies," *Communications Research,* 15, 1988, 603-631.

Leonard-Barton, D. "Implementation as Mutual Adaptation of Technology and Organization," *Research Policy,* 17, 1988a, 251-267.

Liker, J.K., Roitman, D.B., and Roskies, E. "Changing Everything All at Once: Work Life and Technological Change," *Sloan Management Review,* 28(4), 1987, 29-47.

Mackay, W. "Users and Customizable Software: A Co-Adaptive Phenomenon," Ph.D. Thesis, MIT Sloan School of Management, Cambridge, MA., 1990.

Martin, J. *Strategic Data Planning Methodologies.* Englewood Cliffs, NJ: Prentice Hall, 1982.

Martin, J. *Information Engineering.* Englewood Cliffs, NJ: Prentice Hall, 1990.

Miles, M.B., and Huberman, A.M. *Qualitative Data Analysis: An Expanded Sourcebook.* Thousand Oaks, CA.: Sage Publications, 1994.

Miller, D. "Evolution and Revolution: A Quantum View of Structural Change in Organisations," *Journal of Management Studies,* 19(2), 1982, 131-151.

Miller, D. and Friesen, P. "Structural Change and Performance: Quantum vs. Piecemeal-incremental Approaches," *Academy of Management Journal,* 25, 1982, 867-892.

Miller, D. and Friesen, P. "Momentum and Revolution in Organisational Adaptation," *Academy of Management Journal,* 23, 1980, 591-614.

Ollman, B. *Alienation.* Cambridge, UK: Cambridge University Press, 1971.

Opper, S. and Fersko-Weiss, H. *Technology for Teams: Enhancing Productivity in Networked Organizations.* New York: Van Nostrand Reinhold, 1992.

Orlikowski, W.J. "CASE Tools as Organizational Change: Investing Incremental and Radical Change in Systems Development," *MIS Quarterly,* 17, 1993, 309-340.

Orlikowski, W.J. "Learning from Notes: Organizational Issues in Groupware Implementation," *Proceedings of the Conference on Computer Supported Cooperative Work,* Toronto, Canada, 1992, 362-369.

Pennings, J. "Information Technology in Production Organizations," *International Studies of Management and Organization,* 17(4), 1988, 68-89.

Pettigrew, A., Ferlie, E., and McKee, L. *Shaping Strategic Change.* Newbury Park, CA.: Sage Publications, 1992.

Quinn, J.B. "Managing Strategies Incrementally," *Omega*, 10, 1982, 613-627.

Quinn, J.B. *Strategies for Change: Logical Incrementalism.* Homewood, IL: Irwin, 1980.

Rogers, E.M. *Diffusion of Innovations* (2nd. ed.). New York: Free Press, 1983.

Rogers, E.M. *Diffusion of Innovations.* New York: Free Press, 1962.

Rogers, E.M. *Communication of Innovations: A Cross-Cultural Approach.* New York: Free Press, 1971.

Rousseau, D.M. "Managing the Change to an Automated Office: Lessons from Five Case Studies," *Office: Technology and People,* 4, 1989: 31-52.

Seeger, J.A., Lorsch, J.W. and Gibson, C.F. *First National City Bank Operating Group*, Cambridge, MA: Harvard Publishing, 1971.

Sviokla, J.J. "Managing a Transformation Technology: A Field Study of the Introduction of Profiling," Harvard Business School, Boston, MA, June, 1992.

Tushman, M.L., Newman, W.H., and Romanelli, E. "Convergence and Upheaval: Managing the Unsteady Pace of Organizational Evolution," *California Management Review*, 29(1), 1986, 29- 44.

Tushman, M.L., and Romanelli, E. "Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation," in L.L. Cummings and B.M. Staw (Eds.), *Research in Organizational Behavior* (7), Greenwich, CT: JAI Press, 1985, 171-222.

Tyre, M.J., and Orlikowski, W.J. "Windows of Opportunity: Temporal Patterns of Technological Adaptation," *Organization Science,* 5, 1994, 98-118.

Tyre, M.J., and Orlikowski, W.J. "Exploiting Opportunities for Technological Improvement in Organizations," *Sloan Management Review,* 35(1), Fall 1993, 13-26.

Van de Ven, A.H. "Managing the Process of Organizational Innovation," in G.P. Huber and W.H. Glick (Eds.) *Changing and Redesigning Organizations*, New York: Oxford University Press, 1993, 269-294.

Walton, R.E. "Diffusion of New Work Structure: Explaining Why Success Didn't Take," *Organizational Dynamics,* 3(3), 1975, 3-22.

Yourdon, E., and Constantine, L.L. *Structured Design.* New York: Yourdon Press, 1978.