AN EVALUATION OF MANAGERIAL STRATEGIES FOR DEALING WITH WORK PRESSURE IN A PROJECT ORIENTED ENVIRONMENT

by

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ABSTRACT

Many modern organizations operate in a highly unpredictable environment characterized by rapid technological and market changes. Organizations respond to this environment by establishing project teams to deal with the new unstructured problems. When the rate of change reaches a sufficient level, departments such as Research and Development groups and Information Systems groups are established to deal with such problems on a continuous basis. The nature of the tasks in such departments is entirely different from anything managements have previously had to deal with. New skills must frequently be learned in the process of completing tasks and it is difficult to estimate beforehand the time required to complete a task. There are strong forces pulling in the direction of underestimation, which leads to mounting work pressure when due dates are endangered. Management is, therefore, often faced with decisions in which it must trade off the short term goals of schedule and cost against the longer term goals of quality and staff competence. The distinctive character of the project environment has been highlighted through the formulatior of an Industrial Dynamics Model.

Applying managerial strategies established in a more traditional environment to the new situation has often led to disastrous results. The aim of the study is to allow management to experiment with strategies that are better suited to the new environment. Based on the sample strategies tested, it appears that management must pay special attention to the competence goal structure and relieve work pressure by means other than allocation of the personnel away from competence building activities to actual work effort. The model suggests that flexible due dates, when possible, and rapid reduction of project inflow are superior strategies to reduction of the work pressure by extra work effort.

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CHAPTER 1

WORK PRESSURE IN A PROJECT ENVIRONMENT

The environment of many modern organizations is characterized by rapidly changing, sophisticated technology and an uncertain competitive market. As a result, the organizational leadership is confronted with a steady stream of unstructured problems, requiring a high level of technical and conceptual sophistication for their solution. As a first attempt to cope with such problems, management may establish temporary project teams to deal with, for example, product innovation, replacement strategy, and organizational design. As the speed of the environmental changes increases, many temporary project teams become permanent additions to the organizational structure, charged with the responsibility of tackling a continuous stream of unstructured problems. Present examples are Research and Development departments and Information Systems departments.

The nature of the work in a project department is quite different from the traditional tasks in functional departments working in a relatively stable environment. The unstructured character of the problems implies that new and untried solutions must be found, and frequently new skills must be learned as a part of carrying out a task. The elements of newness and

inexperience with similar problems make it very difficult to estimate beforehand the time required to complete a task. It becomes exceedingly unlikely that a state of steady work flows together with an adequate stable staff is reached, as is frequently the case in a more traditional environment.

The organizational slack that is so useful in absorbing unforeseen events and pressures rarely exists in a project environment. There are strong psychological forces pulling in the direction of underestimating the magnitude of unstructured problems. To begin with, it takes a relatively optimistic personality type to tackle ambiguous, unstructured problems. Frequently, the organizational procedures for project approval encourage underestimation. A further reason is that the type of person who can perform in an unstructured environment and solve complex problems is expensive. Management is, therefore, inclined to understaff in order to keep down the cost. Even if management was willing to pay for slack, competent staff may be hard to find.

It is well known from queuing theory that when the slack is taken out of a system, it becomes highly unstable. Project managers are, as a consequence, frequently faced with situations in which the work load builds up beyond some desired level and

delivery dates are being endangered. The term Work Pressure[1] is used here to describe deviations in the work load from the level desired by management. Work pressure in this sense refers to too small as well as too great a work load, although it is considered more likely that the work load will be greater than desired.

Applying managerial strategies that worked well in the more traditional environment under these new circumstances has, in many cases, yielded disastrous results. An understanding of the distinctive features of project management can only lead to a better basis for developing strategies that are appropriate for the new dynamic environment.

The present study is directed towards a conceptualization of the basic managerial processes underlying project management. The focus is on the project organization that must deal with a continuous stream of projects with a time duration of from 2 - 4 years. The time horizon for the study is 10 years. The scope of the study is limited to the conceptual level, and it is not expected that the result will be directly operationally applicable.

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1 The concept of work pressure is similar to the concept of stress used by Fitts and Posner, page 33, where stress is defined by a specification of the demands that the environment places upon the individual.

What is hoped for, however, is that the study will highlight sufficiently the distinctive character of the new environment. To accomplish this, an Industrial Dynamics model[2] will be developed to provide a framework within which the dynamic characteristics of the project environment can be illuminated.

For purposes of illustration some sample strategies for dealing with work pressure will be simulated. It is only proper to emphasize at this point that the value of the study can only be measured by the extent to which people concerned with project management accept the general model framework, adapt the model parameters to their own special circumstances, and begin to test strategies of their own choosing on the basis of the model.

The deliberate simplicity of the model is intended to assist the project manager in sharpening his focus on what his role is and on the activities towards which his efforts should be channeled. It is designed to encourage attempts to use the simplified model as a basis for initial experimentation and for further elaboration.

The background for the specific model formulation is an Information Systems department in a large industry. However, the basic elements of the managerial process are identical in any project environment be it aero-space production, research

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2 Jay W. Forrester, Industrial Dynamics, M.I.T. Press, Cambridge, 1961.

and development, or any other task that requires a large amount of learning in the process of accomplishing the task.

1.1 THE ELEMENTS OF THE MANAGERIAL PROCESS

The managerial process[3] is most often described as an iterative process in which DECISIONS are made in the light of discrepancies between the GOALS and the MEASURED STATE of the ENVIRONMENT. The decision leads to ACTION which in turn affects the measurement and the process continues. This process is illustrated in Figure 1.1.

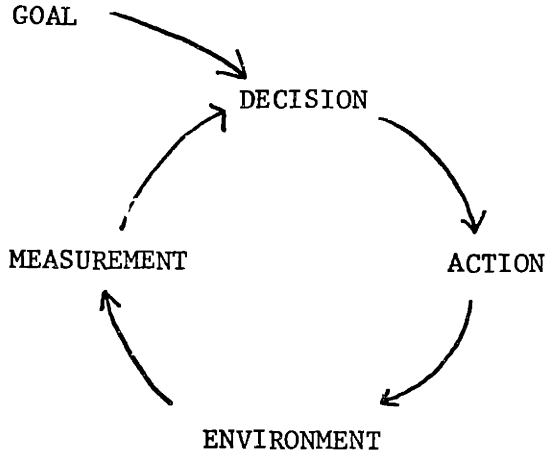

Figure 1.1

Schematic of the Managerial Process

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[3] Carl V. Swanson, "Some Properties of Feedback Systems as a Guide to the Analysis of Complex Simulation Models" (Prepared for Department of Defense Logistics Research Conference, Warrenton, Virginia, May 26, 1965), page 3.

The managerial success - following this simplified model - depends on the quality of the operational goals, the clarity with which they are perceived and communicated, the quality of the decisions, the time delay from the point when the need for corrective action is recognized and the action is taken, the proper implementation of decisions, and the accuracy and timeliness of the measurement.

The above concept of the goal structure is over-simplified. Therefore, the framework will be gradually expanded in the following pages to bring it to a level of complexity where it will be operationally useful for the discussion of the managerial processes as they relate to project management.

The single goal structure is too narrow because management - as politicians - must practice "the art of the possible". Management may have goals to which it aspires, but which it recognizes may not be reached immediately because of some practical constraint. For practical purposes it defines, for itself, operationally practical goals somewhere between the aspiration level[4] and the past performance. Instead of having

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[4] Aspiration level is defined, as it is by Cyert & March, page 115, as being being the weighted function of the organization's past goal, the organization's past performance, and the past performance of other "comparable" organizations.

one goal there may be different orders of goals.[5]

Furthermore, the goal structure is not static, but is continually in motion as the different elements interact over time, as illustrated in Figure 1.2.

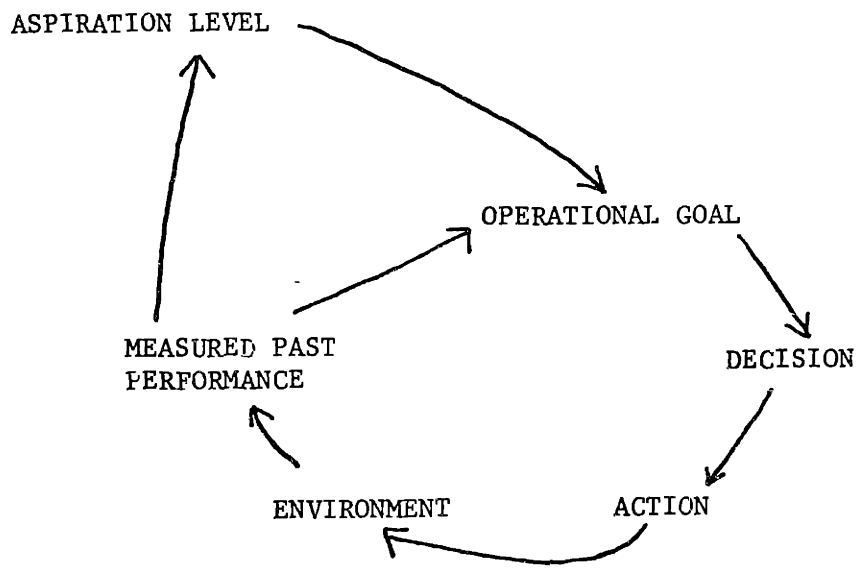

Figure 1.2

Managerial Process with Two Orders of Goals[6,7,8]

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5 Different orders of goals are related to the organizational levels where they originate. One can think of the objectives of the organization as being the highest order of goals. Following Simon's concept of goals, the higher order goal imposes constraints on the next organizational level and the goals become increasingly specific and detailed as one moves down through the organizational hierarchy. [Chapter 4 - Administrative Behavior]

6 For a discussion of this goal structure see Cyert & March, Chapter 3.

7 A more formal documentation is embodied in H. Helson, Adaptation-Level Theory, pages 52-63. The relationship of the aspiration level concept of Cyert & March to the Adaptation-Level of Helson is explained in Helson, pages 117-118.

8 See also J.D. Thompson and W.J. McEwen, pages 23-31.

Within the framework of Figure 1.2 it is clear that maintenance of high long-term performance becomes a question of management's ability to set worthwhile goals and its perseverance in maintaining a high but relevant aspiration level. Even this formulation is not adequate as will appear as these basic points are elaborated to relate them to project management.

Let us assume that management has, as an objective, a high long-term performance level, because earnings and the ability to survive in a competitive environment depend on performance. It is a relatively high order goal and it is not operational for guiding day-to-day managerial behavior.

Management must examine the key elements that go into maintaining long term performance and specify operational subgoals that might be used to guide the organization towards the long term objective. The subgoals of primary interest are delivery dates, cost and quality of the individual projects and the maintenance of a competent staff to deal with projects on a continuous basis. Without a competent staff, delivery dates, cost and quality goals cannot be reached. Schedule and quality are of concern, because to a large degree, they determine the

inflow of new tasks. Schedule and cost are both important as a means of maintaining a satisfactory earnings level.

The goal structure depicted in Figure 1.2 is incapable of explaining the effect of the subgoals. The main problem arises when more than one goal has to be satisfied and the goals are conflicting in the short run. When pressures arise within the organization, management must choose which subgoal is more important and make decisions accordingly.

The main subgoals of the project organization, i.e., cost, schedule, quality and staff competence have the property of presenting management with conflicting goals when the system becomes overloaded. On the one hand, is the short term goal of completing the project on time at a reasonable cost. On the other hand is the short term goal of quality as well as the long term goal of maintaining staff competence and morale through on the job training, formal education and supervisory guidance. This further elaboration of the goal structure is illustrated in Figure 1.3.

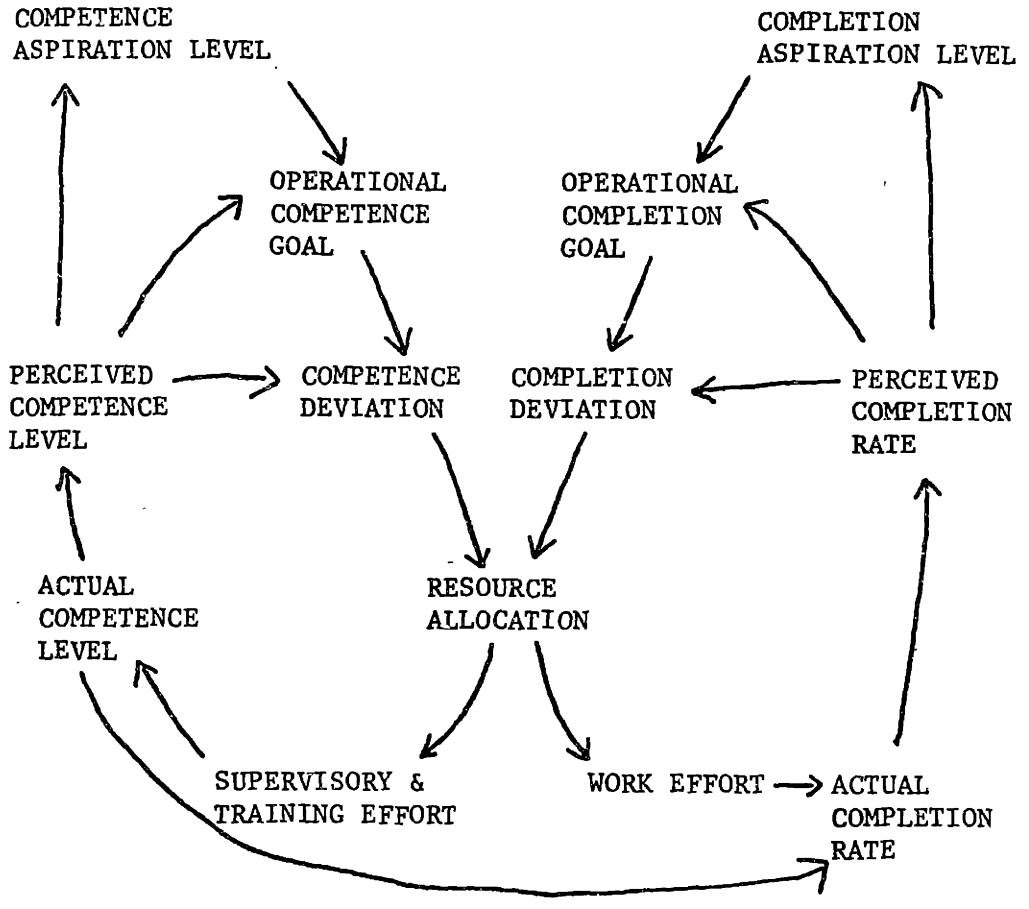

Figure 1.3

Managerial Process with Conflicting Subgoal Structures

For the purposes of model simplification, the schedule and cost goals have been combined into a project completion goal, because they are closely interrelated through factors such as

overtime, penalties for late completion and capital tied up in projects in progress. The quality and competence maintenance have been combined into the competence goal structure, because of the close logical relationship between these two discussions.

Apart from linking the two goal structures together via the allocation of the staff and making the connection between competence and work efficiency, the structure in Figure 1.3 distinguishes between the actual status and the perceived status of the projects. The goal structures and relationships illustrated in Figure 1.3 will be linked more closely to project management.

The focus of the model is on the managerial process. The study is directed toward the process of managerial goal setting, the effect of different degrees of clarity of the goals, the relative emphasis given the two goal structures, the relative weight attached to the aspiration level over past performance, and the managerial inclination to alter the goals as the performance level changes. Furthermore, the effect of more or less vigorous control procedures for monitoring the system status will be investigated.

The model formulation is intended to study the managerial process in its "pure" form. The possibility of changing the staff size as a means of coping with work pressure has been

disregarded as has the effect of client reaction to project performance on the inflow of new projects. It is assumed that the project organization will obtain as much work as management is willing to undertake. The work load will, therefore, be a managerial decision variable.

These exclusions are made in order to keep this initial model formulation simple so that the effects of alternative strategies in the most basic managerial processes may be better understood. By incrementally elaborating the model by allowing for personnel turnover and the effect of client response to the product or service provided, or any other relevant factor, the project manager can develop a tool of increasing operational usefulness as an aid in his development of appropriate strategies for his specific environment.

The relative emphasis given the two goal structures can be represented by the response in terms of resource allocation to deviations from the two goals. It is implied here that the total resources can be allocated to project work or training, education, and supervision. It is recognized that these uses of time are not always mutually exclusive. It does point out the basic fact, however, that supervisory and personnel time must

be devoted to maintaining competence and learning new skills.

The clarity with which the goals are communicated can be reflected in the comparison of the observed condition of the project to the operational goal. If the goal is unclear, as is frequently the case, the perception of the actual status is hazy and therefore the comparison is not sensitive over a wide range of performance. In the case of project management, unclear goals do not necessarily reflect poor management. Some lack of clarity and ambiguity will always be present because of the unstructured nature of the environment.

Management's inclination to adjust its goals in response to actual project pressures - the deviations from the operational goals - can be shown by the relative weight given the perceived performance compared with the aspiration levels. This gives rise to Operational Goals, which are weighted averages of the Aspiration Level and the Perceived Performance. As the Aspiration Level represented what management considered it ought to be able to do in the light of its own past goals, past performance, and comparisons with other comparable organizations or reference groups, so the Operational Goal represents the compromise between what it ought to do and what is practically possible in the short run. This is a recognition of the fact

that managerial actions frequently are taken to yield benefits that may take a long time to materialize. In rare instances the Aspiration Level, the past performance and the Operational Goal may be identical.

The vigor with which project progress is monitored can be established by the delay in the managerial perception of the actual performance. Because of the complexity of the tasks, it is impossible for management to know, at any one time, the exact status of any project, or the exact competence of its staff. On unstructured problems with a project duration of from 2 to 4 years, this problem is aggravated by the fact that it is almost impossible to develop objective standards. It is very easy to build in biases in the perception of project status, and in this regard the control procedures, the reward systems, and the supervisory style can have a great impact on how well the actual status is communicated to the manager. The discrepancy between the actual and the perceived status is normally sufficiently great to make it necessary to distinguish between the Actual Performance and the Perceived Performance in order to properly describe the system behavior. The Perceived Performance will naturally reflect the Actual Performance, but the perception will lag behind the Actual Performance, the

length of the lag depending on the clarity of the task definition, the control procedures, the reward system, and the supervisory style.

The effect of the quality on the completion is seen as operating through the competence of the personnel involved. It is reasonable to assume that high quality performance has a positive effect on the speed with which projects are completed, because many false starts are avoided. Furthermore, there is evidence that people will work more effectively when they feel competent about their ability to do the job.[9,10]

The question at this point is whether the most important dimensions have been included in the model, whether they are linked in a valid fashion, and how one can interpret the results arising from a simulation of the environment as described.

Given the limited scope of the study the model cannot be objectively validated. Therefore, one must rely, to a large degree, on the logic of the preceding model development, which is based on recognized and relatively well documented findings of researchers in Organizational Psychology. A further

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[9] R.W. White, "Ego and Reality in Psychological Theory", New York, 1963, pp. 33-43.

[10] Lance Kirkpatrick Canon, "Self Confidence and Selective Exposure to Information", Conflict, Decision, and Dissonance, ed. Leon Festinger (Stanford, Calif., 1964) pp. 83-96.

validation will be made on the basis of the simulation runs, by verifying the plausibility of the interactions observed between the relevant variables.[11] If in fact the model generates the kind of behavior that one can observe in project organizations, despite the simplicity of the model structure, the results of the simulation runs should provide the desired food for thought on the part of project managers. The more the results resemble the patterns observable in project departments, the more likely it will be that the crucial elements of the project environment are represented in the model.

Having described the elements of the managerial process which are of interest in the present context, a specification of some sample strategies available to management may be attempted.

1.2. MANAGERIAL STRATEGIES FOR DEALING WITH WORK PRESSURE WITHIN FRAMEWORK OF CONFLICTING GOALS

The managerial style and strategies within the framework suggested in Figure 1.3 can be reflected in the following

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11 Jay W. Forrester, Industrial Dynamics, M.I.T. Press, Cambridge, 1961, Chapter 13.

factors:

1. Willingness to alter the competence aspiration level.
2. Willingness to alter the completion aspiration level.
3. Weight given the competence aspiration level relative to the perceived competence level.
4. Weight given the completion aspiration level relative to the perceived completion rate.
5. Closeness of the control of the actual competence level, giving rise to the perceived competence level.
6. Closeness of the control of the actual project progress, giving rise to the perceived completion rate.
7. Reaction, via resource allocation, to deviation between the perceived competence level and the desired competence level.
8. Reaction, via resource allocation, to deviations between the perceived completion rate and the desired completion rate.

9. Reaction, via project acceptance, to deviation between the perceived competence level and the desired competence level.
10. Reaction via project acceptance, to deviation between the perceived project progress and the desired completion rate.

The effectiveness of alternative strategies in maintaining high long term performance may be tested under different conditions for the creation of work pressure. One may assume, for example, that the work pressure is changed because of an underestimation of just one job resulting in a 20% increase in the workload. Another source of work pressure may be a systematic bias in the estimation of accepted tasks, because of the optimism and desire to prove its abilities exhibited by the project staff, or a tendency to do just a little more than was initially intended.

Assuming that just 3 alternatives for each of the 10 factors mentioned were tested under just the 2 conditions mentioned, the possible combinations would be $2x\ 3^{10}$ or 118,098 different strategies. It would not be feasible to test that many strategies within the framework of this study.

Given that no formal techniques exist for approaching the problem of finding a "best" solution, it becomes necessary to rely on some heuristic scheme for an analysis of the problem at hand. The intention is to begin the analysis by formulating a relatively neutral strategy in relation to the two goal structures. This will be done in Chapter 2. In Chapter 3, two major distinct strategies will be outlined, one focussing the attention on the problems associated with the competence goal structure and one focussing the attention on the completion goal structure.

The effectiveness of a strategy will primarily be measured by the accumulated output over a 10-year time horizon. Secondarily, the strategy will be evaluated for its ability in terms of the degree to which the variables of interest deviate from the desired goals, and the ability to maintain the competence level in the long run.

Through an analysis of these initial strategies, it may be possible to isolate the elements of the managerial process that provide the greatest leverage in dealing with work pressure. It may then be possible through a process of incremental changes to the strategies outlined to reach some general conclusions on what constitutes effective strategies

within the scope of the present study. This will be attempted in Chapter 4.

Having isolated the main leverage points available to project management, some general guidelines for operational procedures to guide management in the pursuit of the best strategy will be outlined in Chapter 5. The conclusions of Chapter 5 will indicate possibilities for elaborating the model to make it operationally more useful.

CHAPTER 2

DETAILED DESCRIPTION OF A SIMULATION MODEL OF A TYPICAL PROJECT ENVIRONMENT

The purpose of this chapter is to elaborate the model shown in Figure 1.3 into a detailed model which may be used for the simulation of alternative strategies for dealing with work pressure and experimentation with new approaches.

The model will be formulated within the context of a specific environment. However, any environmental characteristics may be reflected in the model, and strategies pertinent to other specific project environments may be tested.

The specific background for the model developed here is a systems development department in a large industry. The department consists of about 25 programmers and analysts and the work includes business systems as well as engineering applications. The field is a rapidly changing one with respect to hardware and software technology and solution techniques. The rate of knowledge obsolescence is high.

The detailed model development will be divided into three main parts: 1) maintenance of the competence goal, 2) maintenance of completion goals, and 3) allocation of the resources between competence maintenance and work effort in response to pressure from the two goal structures.

The model will be formulated so that it is in perfect balance initially. The inflow of new work is exactly equal to the outflow and all goals are exactly met by the actual and perceived system status. The resources are being allocated in such a manner that the balance is maintained. New skills and knowledge are being acquired in exactly the rate required to maintain the competence level in the face of rapid obsolescence of old knowledge and skills. The initial formulation will reflect a neutral strategy, i.e., one in which the two goal structures are given equal emphasis as regards reaction to deviations from the operational goals.

2.1 MAINTENANCE OF THE COMPETENCE GOAL

The competence dimension must be somehow quantified in order to simulate the competence goal behavior over time. It is a task not easily accomplished in a concrete fashion but it is possible to think about competence in the abstract. Assume, for example, that the management of the systems department follows the technological and technical developments in the field of computers, information systems, and quantitative techniques. It finds that much of the advanced work is quite far beyond usefulness to it at the current time, but it appreciates that some developments would be relevant to it.

It establishes an aspiration level that allows it to keep up with the developments. Assume further that management knows from experience that useful new techniques and technology develop at a relatively steady rate over time. In other words, the techniques and methods presently used within the departments become obsolete in terms of the new goals. Although the frontier of knowledge within the relevant field is not known in any detail, management must somehow ensure that it does not fall too far behind the state of the art. Competition will, in most cases, set the minimum level of competence that the organization can afford. In effect, management must strive to keep up with the frontier of knowledge within its field. Conceptually, management may consider its aspiration level to be the point where the developments in the field are perceived as of most relevance to it, and in the model formulation one may set that competence level equal to some arbitrary figure on a nominal scale, e.g. 100. If the rate of new developments makes the old methods and techniques obsolete at a rate of 2% per month, which is reasonable in systems development, management must devote enought time to competence development so that the 2% loss in relation to the relevant goal is replaced by enough new knowledge for the department to maintain its relative

competence. A 2% obsolescence per month implies a complete replacement of techniques and technology every 4 years.

The arbitrary competence level of 100 may be referred to as 100 competence units. In the more concrete sense it consists of the staff's knowledge and skills of such things as systems analysis, decision models, quantitative techniques, the confidence with which they master the skills, and the ability to work with the user departments in the application of the knowledge and skills which the staff possesses.

Maintenance of the competence goal in this sense refers to the ability to maintain a competence level relative to the environmental opportunities offered. It involves the acquisition of new skills and knowledge, development of confidence in the ability to use the acquired skills and knowledge, and maintenance of a proper working relationship with the people involved in the development, testing and implementation of new solutions. The competence goal structure is represented in detail in Appendix A.

The detailed formulation follows closely the overview in Figure 1.3. The managerial aspiration level is modifiable over time in the light of the perceived past performance, its own past goal, and comparisons to the developments among competition and universities. The speed with which management

adjusts its aspiration level to the perceived competence level is a reflection of the managerial characteristics. It has to do with management's tolerance for discrepancy between what it sees as the state of the organization and what it would like to see. If this tolerance is low there will be a great pressure to rationalize a reduction in the aspiration level to conform more closely to the perceived state. Besides reflecting the tolerance for the deviation between the perceived state and the aspiration level, the speed with which the aspiration level is being adjusted reflects the clarity with which management defines the aspiration level. If it has only a vague notion of where it would like to be, the adjustment will be much faster than if the aspiration level is sharp in the minds of management, i.e. if it recognizes precisely the skills that the organization ought to master. The time it takes to adjust the aspiration level to the perceived competence level has been denoted "Willingness to change the Managerial Competence Aspiration" and has been set at 24 months, reflecting a relatively committed management. In the above formulation, it has been assumed that the "Willingness to change the Managerial Competence Aspiration" is a constant given the characteristics of the management. It is likely,

however, that it would be affected by the work pressure also. Since the aspiration level depends on management following the developments within its field, it is possible that a high work pressure will make management lose touch with the outside environment and therefore be led to a faster acceptance of its own performance as a satisfactory aspiration level.

The equation[12a] for the competence aspiration level may be written as follows:

MCA.K = MCA.J + (DT) (CMCA.JK)	Eq	1	L
MCA = 100 Competence Units	-	1.1	N
CMCA.KL = (1/WCMCA)(PCL.K - MCA.K)	-	2	R
WCMCA = 24 months			

MCA - Managerial Competence Aspiration - Competence Units

CMCA - Change in Managerial Competence Aspiration - Competence Units

WCMCA - Willingness to Change Managerial Competence Aspiration - Months

PCL - Perceived Competence Level

The equation numbers on the right refer to the numbers on the detailed model chart in Appendix A.

The perceived competence level represents management's current perception of the competence of the department. Given

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12a Pugh, Alexander L., III, DYNAMO User's Manual, The M.I.T. Press, Cambridge, Mass., 1961.

the size of the staff, management will not know, at any one point in time, the exact abilities of the staff. Instead, the perception of what the competence level is, will be obtained through observing the quality of work being accomplished. The process of observation is normally carried out through presentations or progress reports or through consultation. The delay in the managerial perception in relation to the actual competence level is, therefore, a reflection of both the kind of interaction there is between the management and staff, and the clarity with which management sees competence. If it has very unclear ideas about the competence needed or how to evaluate the staff, the delay will be great. What may happen in the extreme case is that the staff may work for a very long time on a project only to discover, at the implementation stage, that the whole effort was wasted. This delay - called "Time to change Perception of Competence Level" - has been assumed to be a constant. This assumption may not be valid in all cases because when the work pressure builds up management must frequently attend to one crisis situation after another. The time spent interacting with the staff is often reduced sharply with the result that management loses touch with the status of its staff. The delay increases. Occasionally

the increased work pressure may reach a point where management is forced to completely reevaluate projects and the staff assigned to it. In such cases, the delay is reduced. On the average it may, therefore, be reasonable to assume the delay to be constant. The delay has been set initially at 12 months, reflecting a management style in which most of the contact with the staff is via formal presentations with only occasional consultation, and not too clearly perceived criteria for what constitutes good performance.

The equations for the perceived competence level are:

PCL.K = PCL.J + (DT)(CPCL.JK)	Eq	3	L
PCL = 100 Competence Units	-	3.1	N
CPCL.KL = (1/TCPCL)(ACL.K - PCL.K)	-	4	R
TCPCL = 12 months			

PCL - Perceived competence level - competence units

CPCL - Change in perception of competence level - competence units

TCPCL - Time to change perception of competence level - months

ACL - Actual competence level - competence units

Management must compromise between its aspiration level and the perceived competence level. It must evaluate how quickly it can move towards the aspiration level given the current status of its staff. It will weigh the two elements and settle for an operational goal towards the achievement of which the resource allocation and project acceptance is directed. In the current formulation, the aspiration level and the perceived competence level will be given equal weights for the formation of the operational competence goal.

OCG.K = (WMCA)(MCA.K) + (WPCL)(PCL.K) Eq 5 A

WMCA = .5 - 5.1 C

WPCL = .5 - 5.2 C

OCG - Operational competence goal - competence units

WMCA - Weight of managerial competence aspiration - dimensionless

WPCL - Weight of perceived competence level - dimensionless

PCL - Perceived competence level - competence units.

The difference between the perceived competence level and the operational competence goal - called "Perceived Competence Deviation" - is what creates the pressure to reallocate resources and change the project acceptance rate.

PCD.K = PCL.K - OCG.K Eq 6 A

RCD.K = PCD.K/OCG.K - 7 A

PCD - Perceived competence deviation - competence units

PCL - Perceived competence level - competence units

OCG - Operational competence goal

RCD - Relative competence deviation - dimensionless

The actual competence level is being reduced by the rate of competence obsolescence and maintained through on-the-job training, formal education, and supervisory guidance.

The rate of competence obsolescence is a reflection of the advances in technology and techniques within the field of endeavor. It is an indication of the fact that a certain percentage - in the model here formulated, 2% - of the current skill and knowledge level is made obsolete by new developments every month or simply forgotten. This rate may not necessarily be a constant from month to month, but it is reasonable to assume that over a time horizon of 5-10 years it will approximate some constant figure.

The rate at which new competence is developed depends on the time (man-months) allocated to training, education and consultation with the supervisory staff[12] as well as

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12 The influence of the supervisory staff on the competence development operates through the feedback given the staff members on their performance.

on the actual competence level. The lower the actual competence, the more effort is required to add another unit of competence. This reflects the fact that if some skill or knowledge is not used and kept current, it is often necessary to start from scratch again, learning basic concepts. This relationship between the actual competence level and the effectiveness of competence learning is reflected in the competence acquisition capability formulated as (Competence Acquisition Factor) (Actual Competence Level)/ (Normal Competence Level). The competence acquisition factor is a constant set at .4 to make the competence developed by allocating 20% of the manpower time to competence development in order to match the rate of competence obsolescence. The normal competence level is set at 100 reflecting the "industry norm" which is also the initial aspiration level.

ACL.K = ACL.J + (DT)(ACDVP.JK - RCO.JK)	Eq	12	L
ACL = 100 competence units	-	12.1	N
ACDVP.KL = (CAC.K)(ACDLP.K)	-	13	R
CAC.K = (CAF)(ACL.K)/NCL	-	11	A
CAF = .4	-	11.1	C
NCL = 100 competence units	-	11.2	C
RCO.KL = ACL.K/NRCO	-	14	R
NRCO = 50 months	-	14.1	C

ACL - Actual competence level - competence units

ACDVP - Actual competence development - competence units

CAC - Competence acquisition capability - competence units/man-months

CAF - Competence acquisition factor - competence units/man-months

NCL - Normal competence level - competence units

RCO - Rate of competence obsolescence - competence units/months

NRCO - Normal rate of competence obsolescence - competence units/months

ACDLP - Allocation to competence development - man months

The assumption that the learning of the required skills - adding competence units - will be more and more difficult as the actual competence level decreases, is the opinion of the author and not a documented fact. It is based on the experience reported from research and engineering laboratories where engineers and other professional personnel have become technically obsolete within a few years after graduation. The result has been that extensive retraining programs have had to be developed which would not have been the case if the new developments had been added incrementally to the basis of skill and knowledge held by the student at graduation.

Whether or not this assumption is in fact valid is not expected to affect the general system behavior.[13]

2.2 MAINTENANCE OF THE COMPLETION GOAL

The formulation of the completion goal structure for simulation must be done at an aggregate level. It is neither feasible nor necessary to consider details of the individual projects undertaken. The main interest is in the managerial reaction to differences between the goals for completion and the perceived completion, given the manpower and competence level. This is sufficient detail to consider general managerial responses or strategies in situations where the goals are not met, and to ask questions about where management will look for solutions to relieve the pressure generated by schedule deviation.

The total work load will be described in terms of work units which may be conceptualized to represent 1 man-month of output at the normal competence level which has previously been set at 100.

The managerial goals can be formulated in terms of total work units to be completed per month and a workload desired

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13 This point was tested by changing equation 11 A to CAC.K = (CAF)(NCL)/ACL.K. While the overall results changed the rank order of the alternative strategies tested in Chapter 2 and 3 remained the same.

by management representing a certain number of months of work given the present staff size and competence. The detailed model is shown in Appendix A. In the case of the systems department used as a basis for the general model formulation, the monthly completion goal will be set initially to 100 work units, which represents 5 work units per man per month for the part of the manpower time that is devoted to work as opposed to competence development. In the initial steady state condition, the allocation to work effort represents 80% of the total time of the staff of 25. The desired backlog of work represents 12 months work, meaning that on the average the incoming projects will take one year to complete.

The Completion Aspiration Level is the managerial aspiration level as far as the departmental productivity is concerned. It is established through comparisons with other similar organizations, through an in-house "objective" evaluation of what ought to be accomplished or through any other means whereby management can obtain clues about a feasible desired departmental performance.

The Completion Aspiration Level will be modified over time in the light of the perceived actual performance.

Management will have a feel for the actual output over a past time period, and the aspiration level will gradually shift toward the actual performance at the same time as management will attempt to influence the actual performance in the direction of the Operational Completion Goal. Management's willingness to alter the aspiration level may depend on its tolerance for deviation between the aspiration level and the perceived actual performance. Some managements will easily rationalize that theirs are special cases and therefore quite rapidly adjust their goals. Others will instead focus on the reasons for the deviation and attempt to work on the cause. As an initial condition, the willingness to change the completion aspiration level will be set at 36 months. (This is equivalent to about 3% of the deviation per month.)

CAL.K = CAL.J + (DT)(CAL.JK)	Eq	16	L
CAL = 100 work units per month	-	16.1	N
CCAL.KL = (1/WCCG)(PCR.K - CAL.K)	-	17	R
WCCG = 36 months	-	17.1	C

CAL - Completion aspiration level - work units/month

CCAL = Change in completion aspiration level - months

WCCG - Willingness to change completion goal - months

PCR - Perceived completion rate - work units/month

The past performance to which management responds is the Perceived Completion Rate. The Perceived Completion Rate is an exponentially smoothed value of the Actual Completion Rate, indicating that in the unstructured environment under study an exact knowledge about the completion rate does not exist. Only by evaluating the output over some time period will management develop an ability to assess the completion rate. The time factor in the smoothing is a reflection of the managerial responsiveness to changes in the completion rate, and will also depend on the degree to which the output may be considered to be stable from period to period. If, in a given environment, the productivity appears to be highly irregular, long time periods will normally be used as a basis for evaluating the completion rate. To the extent that better control procedures and more detailed ways of breaking down the task make it easier to measure the productivity, the managerial control processes will have a strong influence on the length of the smoothing factor. In the case of the systems department, a smoothing factor of 6 months is used.

PCR.K = PCR.J + (DT)(1/TSCR)(ACR.JK - PCR.J)	Eq	18	A
PCR = 100 work units/month	-	18.1	N
TSCR = 6 months	-	18.2	C

PCR - Perceived completion rate - work units/month

TSCR - Time to smoothe completion rate - months

ACR - Actual completion rate - work units/month

Management will normally compromise between the Completion Aspiration Level and the Perceived Completion Rate and set a satisfactory Operational Completion Goal somewhere between the two. The specific managerial characteristics determine how much weight is given the two components. It is not implied that management consciously calculates the operational goal on the basis of weighting factors and explicit statements of the two components, the aspiration level and perceived performance. Rather management more or less consciously responds to the pressure developed in the system by late completions, by adjusting its perception of what is a reasonable expectation to have about project performance.[14] The managerial inclination

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[14] This line of thought is similar to Cyert and March's (page 34) discussion of what they call sequential attendance to goals.

to set the operational goal closer to one or the other of the two goal components determines a large part of the system behavior. The two goals will be given equal weight in the initial formulation.

OCPLG.K = (WPCR)(PCR.K) + (WCAL)(CAL.K) Eq 19 A

WCAL = .5 - 19.1 C

WPCR = .5 - 19.2 C

OCPLG - Operational completion goal - work units/month

WCAL - Weight of completion aspiration level - dimensionless

WPCR - Weight of perceived completion rate - dimensionless

CAL - Completion aspiration level - work units/month

The Operational Completion Goal established through the above mechanism gives rise to a Desired Project Backlog. It is normally desirable to maintain a rather steady workload, and by adjusting the inflow of work, management can maintain the backlog of work it wishes to have. The Desired Project Backlog is set at 12 months of expected output.

When management relates what it believes is the present backlog to the desired backlog, any perceived difference will provide a pressure for management to eliminate the difference. This sort of comparison is a rather vague process,

however, because neither factor is likely to be clearly perceived. The number of late completions is most likely the concrete factor that initiates managerial action. The action may be directed toward reallocating people between competence maintenance activities and direct work effort and through altering the acceptance rate of new projects.

DPB.K = (OCPLG.K)(DMPB)	Eq	20	A
DMPB = 12 months	-	20.1	C
PPD.K = DPB.K - PPB.K	-	26	A
RPD.K = PPD.K/DPB.K	-	27	A

DPB - Desired project backlog - work units

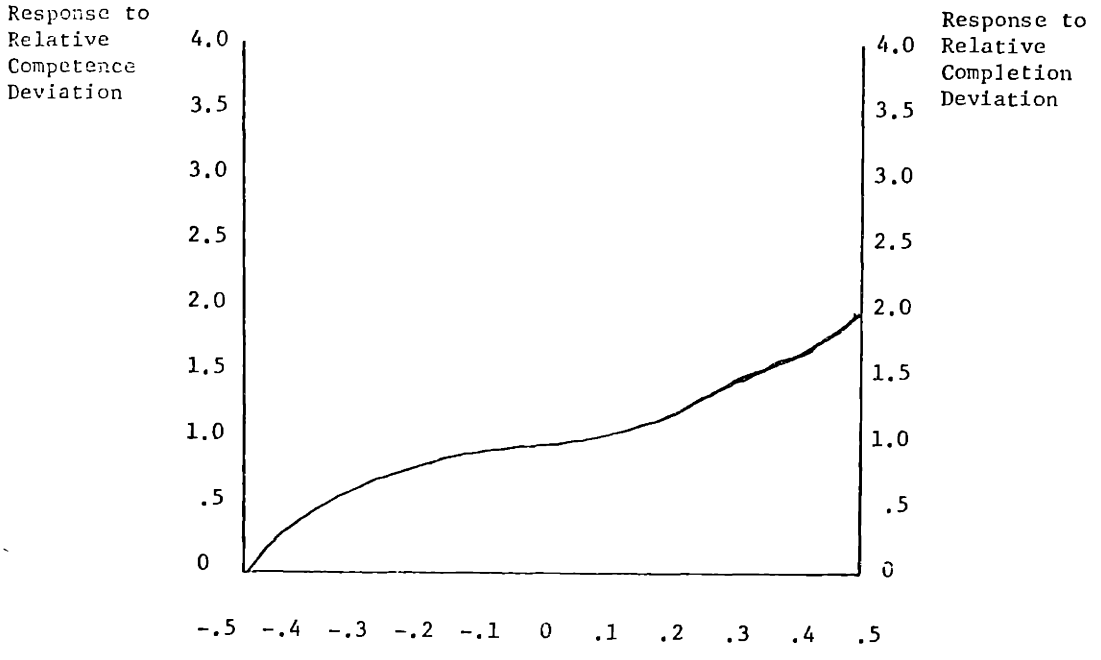
DMPB - Desired months of project backlog - months

PPD - Perceived project deviation - work units

RPD - Relative project deviation - dimensionless

The realization that schedules are not being met usually comes about gradually, and the first signs are not likely to generate much response. Over a wide range around the desired level the reaction is likely to be slight with respect to changes in the acceptance rate of new projects.

The change in the project acceptance rate is illustrated in Table 2.1.



Relative Deviation from Desired Project Backlog and Operational Competence Goal

Table 2.1

Adjustment to Project Acceptance in Response to Deviations from Operational Goals

The rate of project acceptance is influenced by the perceived competence deviation as well. Management will attempt to take the pressure out of the system so that respectively

more or less time may be devoted to competence development, depending on whether the deviation from the operational goal is positive or negative. Table 2.1 also illustrates the effect of competence deviations on project acceptance. In the initial formulation deviations between the desired and perceived status of both goal structures lead to equal reaction on project acceptance. If, for example, the Perceived Project Backlog is 20% greater than desired, management will only accept projects equivalent to 75% of the expected completion rate, in order to bring the workload back to the desired level. If, at the same time, the Perceived Competence Deviation is 10% below the Operational Competence Goal, the Rate of Project Acceptance will be further modified by a reduction of 10% to 67.5% of the Perceived Completion Rate. The effect of the two factors is assumed to be multiplicative.

The rate of project acceptance is guided by the operational completion goal when the system is in balance, and modified by the pressures on competence maintenance and project completion when the goals are not being satisfied.

RPA.KL = (OCPLG.K)(PRPA.K)(PCPA.K) Eq 21 R

PRPA.K = TABLE (TPRPA, RPD.K, -.5, .5, .1) - 28 A

TPRPA* = 0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2 - 28.1 C

PCPA.K = TABLE (TPCPA, RCD.K, -.5, .5, .1) - 8 A

TPCPA* = 0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2 - 8.1 C

RPA - Rate of project acceptance - work units

PRPA - Pressure to regulate project acceptance - dimensionless

TPRPA - Table for pressure to regulate project acceptance - dimensionless

PCPA - Pressure from competence on project acceptance - dimensionless

TPCPA - Table for pressure from competence on project acceptance - dimensionless

RPD - Relative project deviation - dimensionless

RCD - Relative competence deviation - dimensionless

The Actual Project Backlog, initially equal to the desired project backlog, is increased as new projects are being accepted and decreased as projects are being completed.

The Actual Completion Rate depends on the number of people allocated to the work effort and on their competence. A number of work units - set at 5 - is completed per man-month of time devoted to work when the actual competence level is normal.

The relationship between the Actual Competence Level and the effectiveness of the work effort is illustrated in Table 2.2.

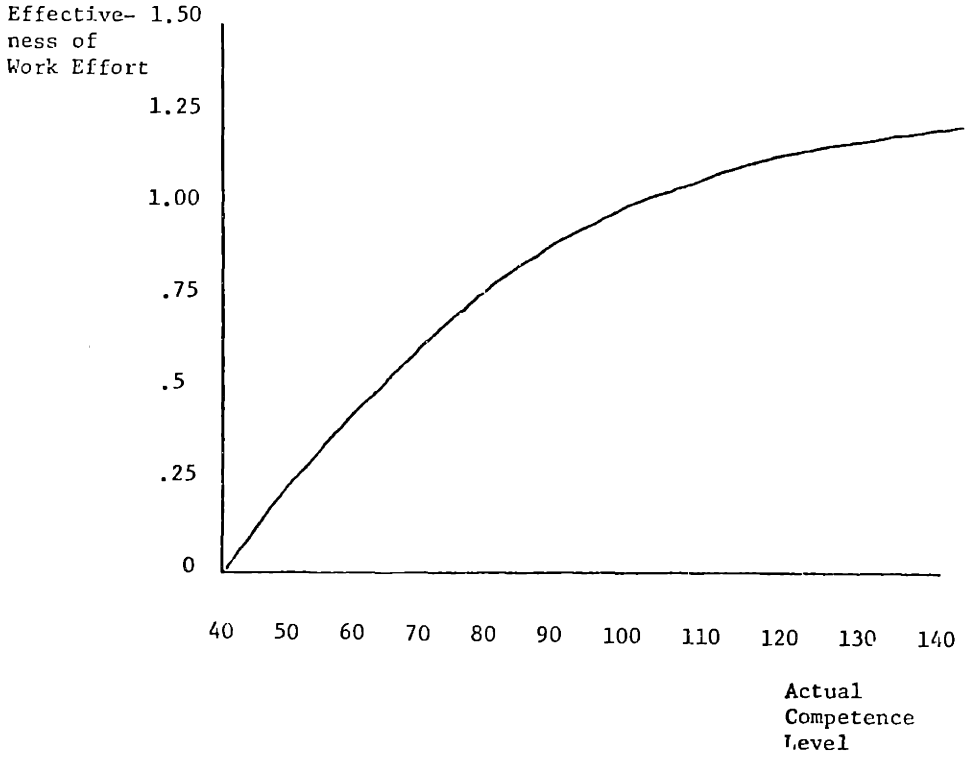


Table 2.2

Competence Effect on Completion Rate

The table illustrates the fact that when the competence falls below a certain level, the staff will be totally unable to

accomplish any task, and also, that beyond some level of competence it becomes irrelevant for the purposes of the particular environment which is being considered. In the interval between these extremes, the relationship between competence and effort is expected to be non-linear, as illustrated. For the purposes of the present study the exact relations are not important as long as the slope of the curve is accepted. The direction of the change in results obtained through policy experimentation will be valid as long as the slope of the curve is positive.[15]

APB.K = APB.J + (DT)(RPA.JK - ACR.JK)	Eq	22	L
APB = 1200 work units	-	22.1	N
ACR.KL = (WUPMM)(AWE.K)(CECR.K)	-	23	R
WUPMM = 5 work units for man-months	-	23.1	C
CECR.K = TABLE (TCECR, ACL.K, 40,140,10)	-	31	A
TCECR* = 0/.23/.42/.6/.75/.88/1/1.1/1.18/ 1.22/1.25	-	31.1	C

APB - Actual project backlog - work units

ACR - Actual completion rate - work units

WUPMM - Work units per man-month - work units

CECR - Competence effect on completion rate - dimensionless

TCECR - Table for competence effect on completion rate - dimensionless

AWE - Actual work effort - men

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15 This statement was tested by changing the Table function in Table 2.2 to a S-curve as follows:
TCECR* = .15/.2/.28/.45/.65/.85/1/1.1/1.2/1.25/1.3.
While the absolute values changed, the rank order of the strategies tested did not.

ACL - Actual competence level - competence units

RPA - Rate of project acceptance - work units/month

The Perceived Project Backlog is the managerial perception of the state of projects. Because it is impossible to monitor every detail of the actual work being done and the progress made from month to month, management will always lag behind in its knowledge of the true status of the projects. How large the lag is will depend on the relevancy and timeliness of the project progress control carried out by management. If only formal processes such as periodic presentations are made, the time lag may be large, may be as high as 12 months (meaning that 8% of the difference between the actual and the perceived level is adjusted each month). If other formal methods such as weekly progress reports, PERT or CPM are used, the lag may be reduced to 6 months and if this is further supplemented by supervisory consultation, it may be as low as 2 months. The lag (Time to Change Perception of Project Backlog) in the case of the systems department used for this model formulation was about 6 months.

PPB.K = PPB.J + (DT)(CPPB.JK)	Eq	25	L
PPB = 1200 work units	-	25.1	N
CPPB.K = (1/TCPPB)(APB.K - PPB.K)	-	24	R
TCPPB = 6 months	-	24.1	C

PPB - Perceived project backlog - work units

CPPB - Change in perceived project backlog - work units

TCPPB - Time to change perception of project backlog - months

APB - Actual Project Backlog - work units

2.3 ALLOCATION OF PERSONNEL BETWEEN COMPETENCE MAINTENANCE ACTIVITIES AND WORK EFFORT

It is recognized that competence maintenance and work effort are not always mutually exclusive. In the environment under study there are, however, many activities which may be considered competence developing that may be reduced or dropped without apparent immediate adverse effects when the organization becomes overloaded. Factors such as documentation of the work done, proper testing of the output, discussion between analysts and users, and field training can easily be sacrificed. So can on-the-job training, programmer/analyst consultation and professional seminars. The departmental supervision may spend time on actual work effort instead of coordinating the personnel activities. It is in this sense that there are allocation considerations in response to pressure from unfulfilled goals.

The allocation of the total resource of 25 men depends on the managerial evaluation of the relative importance of the two goals. One may assume that management applies some weighting factor, but that the relative weight depends on the

perceived status of the two goal structures compared to their operational goals.

Table 2.3. illustrates the allocation of the staff effort to competence development and work effort in response t deviations from the operational goals.

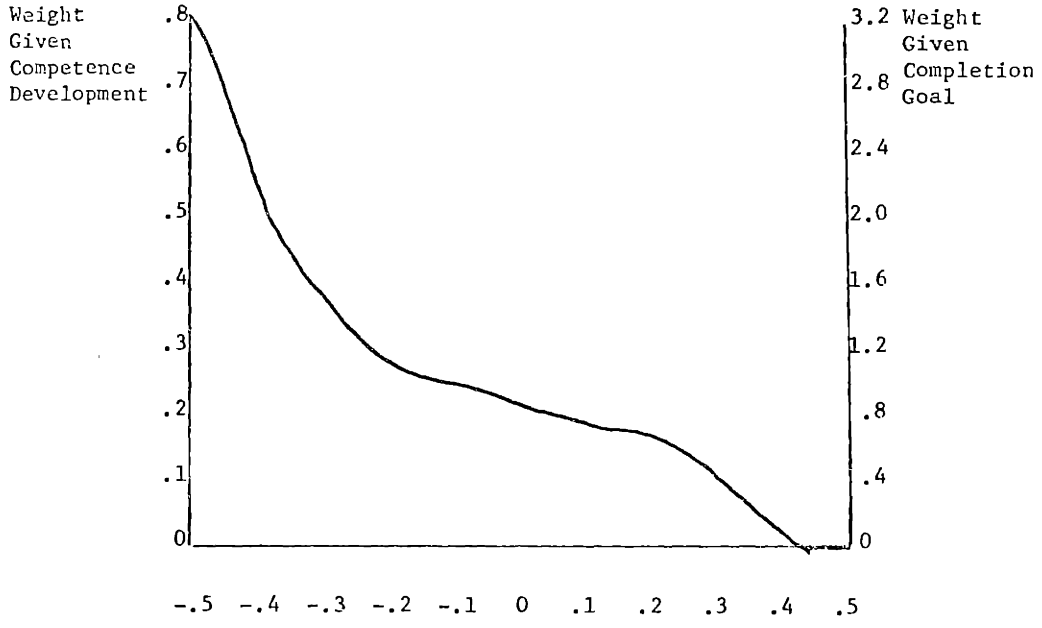


Table 2.3

Allocation of Staff Effort to Competence Development and Work Effort in Response to Deviations from Operational Goals

In the initial formulation, management is assumed to respond in identical fashion to deviations from either operational goal.

The graph indicates that the managerial reaction is relatively small when the deviation from the goal is small, but that it becomes more drastic as the difference increases. Again, it is not implied that management actually operates on the basis of graphs and a firm knowledge of the goal and deviation in any numerical sense. The deviation between what is expected and what is observed regarding competence is recognized through the number of errors and complaints being brought back to the department from users, and found within the department. As long as the complaints are minor, no particular action may be taken, but when the number of complaints or their magnitude increases, pressure will be brought to bear on the correction of the situation.

As in the case of the pressure from competence deviation, the reaction to deviation from the completion goal is not normally great around the goal, but increases more sharply as the deviation becomes greater.

With these relationships defined the equations may be written.

PCCA.K = TABLE (TPACD, RCD.K, - .5, .5, .1)	Eq	9	A
TPACD* = .8/.5/.35/.25/.225/.2/.185/.15/ .08/0/0	-	9.1	C
PCWA.K = TABLE (TPCWA, RPD.K, -.5, .5, .1)	-	29	A
TPCWA* = 3.2/2/1.4/1/.9/.8/.74/.6/.32/0/0	-	29.1	C
TR = 25 men	-	15	L
ACDLP.K = (PCCA.K)(TR)/(PCCA.K + PCWA.K)	-	10	A
AWE.K = (PCWA.K)(TR)/(PCCA.K + PCWA.K)	-	30	A

PCCA - Pressure to change the allocation for competence development - dimensionless

TPCCA - Table for pressure to change the allocation for competence development - dimensionless

PCWA - Pressure to change work allocation - dimensionless

TPCWA - Table for pressure to change work allocation - dimensionless

ACDLP - Allocation to competence development - men

AWE - Allocation for work effort - men

TR - Total resources - men

2.4 SIMULATION RESULT OF A NEUTRAL STRATEGY

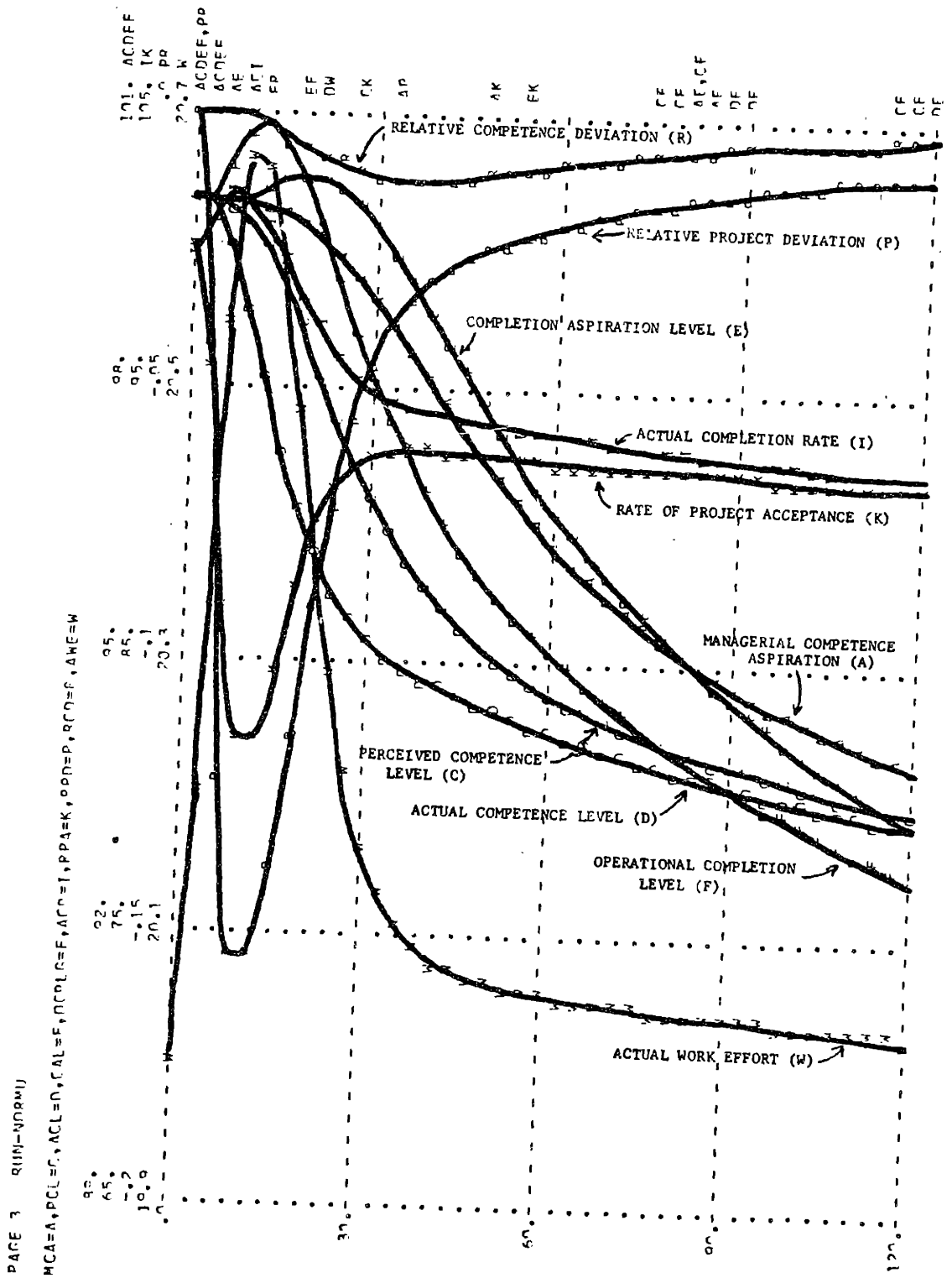
The formulation outlined in sections 2.1, 2.2 and 2.3 may be considered to reflect a neutral strategy because management reacts in the same way, in terms of reallocation of resources and adjustment to project acceptance, to the same relative deviation from both operational goals. Equal weights have

been given perceived performance and the aspiration levels in the formation of the operational goals. It has further been assumed that management has been more inclined to alter the competence aspiration than the completion aspiration, because it is easier to clearly define the completion goal. For the same reason, it is assumed that the delay in perceiving the actual competence level will be longer than the delay in perceiving the actual project backlog and the actual completion rate.

The above managerial strategy has been simulated over a period of 10 years. Initially, the organization is assumed to be in perfect balance, functioning at the aspiration level of both competence and completion goals. In the second month the organization is faced with a project that increases the actual workload by 25% through an underestimation of one project. The simulation Run NORMU illustrates the effect of such a disturbance on the organization. Appendix B gives a complete listing of the DYNAMO program runs for all simulation runs.

The 25% underestimation of the Actual Project Backlog results in a 1500 work units workload instead of the desired 1200 work units at month 2. The simulation run indicates

SIMULATION RUN - NORMU



that because of the lag introduced by the Time to Change the Perception of Project Backlog (6 months), the Relative Project Deviation reaches its peak about 8 months later. With the increased project backlog the Relative Project Deviation becomes negative, indicating that the projects are behind schedule. Management reacts by allocating more staff to work effort and less to competence maintenance, and through an adjustment to the Rate of Project Acceptance the Actual Completion Rate goes up, the Rate of Project Acceptance goes down, and the Actual Project Backlog (not shown on graph) begins to fall as expected. With a delay of 8 months, the Relative Project Deviation also begins to fall. It is noteworthy that while the Relative Project Deviation does not begin to fall until month 10, the Actual Completion Rate begins to fall at month 6 even though the Allocation to Work Effort is still on the rise. What has happened is that with the shift in the allocation of staff time away from competence developing activities, the quality of the work begins to decline and the Actual Competence Level begins to fall. In month 6 this loss of competence is enough to offset the increased Allocation to Work Effort so that the Actual Completion Rate begins to fall.

Within the first year after the initial underestimation, the work pressure has caused a sufficient shift in the allocation of staff away from the competence building activities to work effort to yield an Actual Completion Rate that is below the initial level.

In the meantime, the goal structures have also been affected. The Perceived Competence Level began to fall 5 months after the disturbance occurred, and 6 months later the effect is moticed on the Managerial Competence Aspiration. The Operational Completion Goal started out rising, encouraged by the extra output gained through the reallocation of the staff. This fact partly accounts for the slow rise in the Relative Project Deviation because with the rising Operational Completion Goal the Desired Project Backlog also increases. The falling Actual Completion Rate causes the Operational Completion Goal to fall about 10 months after the disturbance. Because of the managerial reluctance to alter the Completion Aspiration Level, it remains almost constant throughout the first year.

Having described the model behavior during the first year after the disturbance introduced by the 25% underestimation,

it may be useful to return to the issue of model validity and raise the question of how plausible the interactions between the observed variables are.

The Aspiration Levels have shown little change, although the Competence Aspiration Level has just started to decline. The ambiguity in defining clearly the Managerial Competence Aspiration makes this dimension somewhat more susceptible to change and since the Perceived Competence Level is falling following the drop in the Actual Competence Level, this is reasonable.

Given the rapid changes in knowledge and skills required to maintain competence, it is equally plausible that a reallocation of staff time away from competence developing activities will lead to a decline in the competence level relative to the required level.

The initial increase in the Actual Completion Rate following the reallocation of staff is logical as is the slow rise in the Operational Completion Goal. The staff has demonstrated that it can reduce the backlog faster than at the initial level and since the Relative Project Deviation is still greater than desired, management is encouraged to keep the staff working to eliminate the undesired backlog.

This model behavior is also logical, particularly when related to management's persistence in maintaining the original aspiration level. It shows that increasing the operational completion goal is just a temporary measure designed to bring the workload back to the desired level. To further facilitate this, the Rate of Project Acceptance is reduced. Up to this point then, the model behaves like a logical management would behave.

A similar test is applied to the remaining 9 year period. 12 months after the disturbance is introduced, the effect of the reduced competence and of the reduced completion rate begins to be felt on the aspiration levels. Because of the reduction in the Rate of Project Acceptance, however, the Relative Project Deviation begins to decline and, therefore, management slowly begins to accept more projects. At the same time as the Relative Project Deviation is improving management begins to perceive the decline of the competence level as indicated by the Relative Competence Deviation. These two factors combine to affect an allocation of staff back to competence developing activities, resulting in a slow-down of the decline of the Actual Competence Level.

This in turn retards the decline in the Actual Completion Rate.

About 5 years after the initial disturbance the system shows signs of approaching a new equilibrium and this process continues for the rest of the 10 year period.

A few more factors are of interest at this point. While the Relative Competence Deviation, as perceived by management, begins to improve after 3 years, the Actual Competence Level is still declining. The reason for this is that since the Managerial Competence Aspiration is a function of, among other things, the Perceived Competence Level, the Competence Aspiration is under steady pressure downward. Even though it is only lowered slowly, sustained pressure brings it down, and with it, the Operational Competence Goal falls. The improvement in the Perceived Competence situation is, therefore, brought about by the reduction in the rate of decline of the competence level as well as by the gradual lowering of the competence goals.

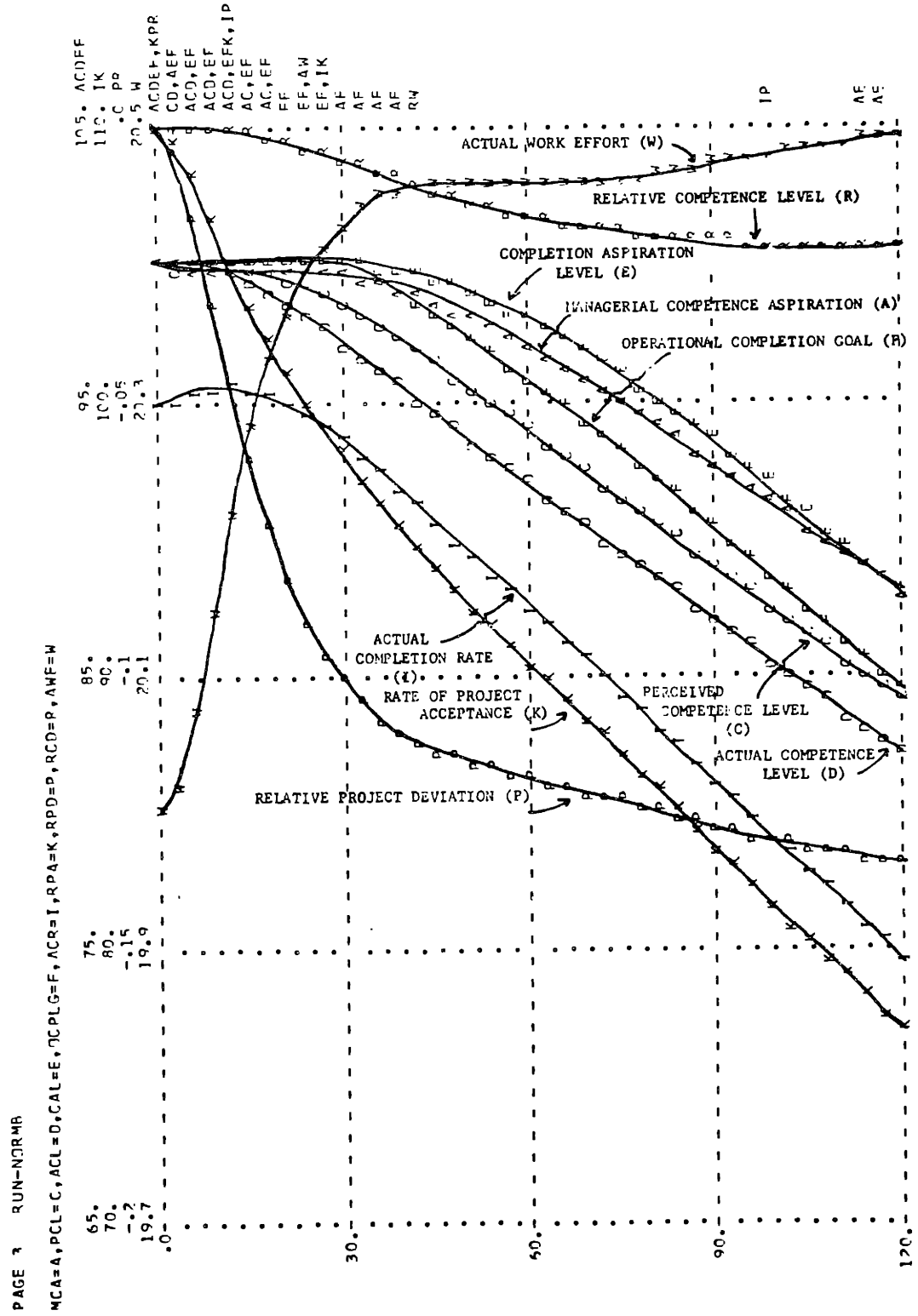
The interactions between the variables during the last 9 years of the simulation described conform quite well to the kind of behavior one can observe in project organizations. The Allocation to Work Effort therefore remains high and the downward pressure is sustained.

The result of the 10 years simulation was a total of 11,355 completed work units and an actual competence level which is stabilizing around 93. compared with the initial 100.

In the simulation run described above, the well balanced project organization was "shaken" by just one large underestimation of the projects undertaken. Now the model will be tested to see how the same organization will react to a continuous bias of 10% underestimation of every project it undertakes. The result of this run - shown in Run NORMB - is an accumulated output of 11,048 work units and an actual competence level of about 82 which is rapidly declining.

It is apparent that a permanent pressure on the staff introduced by the bias forces the same allocation of staff to work effort as observed in the previous run. The declining competence level gradually affects the competence goals in a downward direction so that the relative competence deviation never becomes very great. It is a case where management, because of the pressure it is under, gradually shifts its aspiration level to match more closely its own performance and pays less attention to comparisons with

SIMULATION RUN - NORMB



PAGE 3 RUN-NORMB

MCA=A,PCL=C,ACL=D,CAL=E,DCPLG=F,ACR=I,RPA=K,RPD=P,RCD=P,AWF=W

other organizations for the setting of the competence aspiration level.

Consistent with the greater reluctance to alter the Completion Aspiration Level, the gap between the Perceived Competence Rate and the Operational Completion Goal is kept wider than the gap between the Perceived Competence Level and the Operational Competence Goal, as indicated by the greater Relative Project Deviation.

It is apparent that the project environment is most susceptible to work pressure and that the organization is highly prone to suffer a loss of competence and therefore productivity in the long run because of it. It is striking that it is very easy for the organization to deteriorate, but extremely difficult to improve in an ongoing organization.

The effect of the work pressure may be very slow, but it will gradually allow the competence level to fall and the slowness of the decline makes it almost invisible to management which, just as slowly, becomes used to the new lower level of performance.

The two simulation runs just described have served the purpose of introducing the dynamic behavior of the project environment. They also provided a basis for the part of the

model validation normally carried out by examination of the interactions of the variables under study within specified time periods. Since it is impossible to objectively validate the above model, each individual must, in a sense, make his own judgement about the validity. What has been done, to this point, has been intended to lend credence to the validity of the model by defining the individual model components as logically as possible, drawing on relevant research for support where possible, and by the analysis of the model behavior on the basis of the preceding simulation runs.

CHAPTER 3

EVALUATION OF ALTERNATIVE MANAGERIAL STRATEGIES

Chapter 2 served to introduce the dynamic character of the project environment and to argue the validity of the model within the scope of this study. In this chapter the model will provide a basis for evaluating some specific managerial strategies for coping with work pressure. Two main strategies will be tested; one focussing on the competence goal structure and one focussing on the completion goal structure.

A management concerned with the competence goal structure will be reluctant to alter the competence aspiration level and will weigh the aspiration level heavily relative to the perceived competence level in setting the operational competence goal. This will mean that when management is confronted with deviations between the operational competence goal and the perceived competence level, it will go to great length searching for solutions that will rectify the situation, without lowering the aspiration level. Given the present model formulation in which the possibility of increasing the size of the staff is not considered, this search will logically be directed towards a reallocation of the staff, subject to constraints imposed by the completion goal, and to a change in the acceptance rate

of new projects. The general emphasis on competence will also lead to a close watch by management on the competence level of its staff, leading to a quite accurate perception of the actual competence level. By the same token, the emphasis on competence will lead to a more clearly defined competence goal, indicating a clearer perception of what management wants its staff to master in terms of knowledge and skills. When the goal is clearly defined, management is able to react to even quite small deviations from the goal.

The above characteristics may exist with several alternative strategies on the completion side of the goal structure. It is likely that a competence-conscious management will be quite willing to alter the completion goal, i.e., make schedule changes, in order to relieve the work pressure. However, this willingness to adjust the schedules to perceived past performance may be combined with both loose and close control of project progress, and with a slow and rapid adjustment to project inflow in response to deviations from the completion goal. Close project control is associated with more sensitive reaction to deviations reflecting a clearer goal formulation.

The other major managerial strategy, focussing on the completion goal, is characterized by a greater reluctance to change the completion aspiration level and a high weight attached to the completion aspiration level compared with past performance. There will be tight formal control of project progress, and the completion goals will be relatively well defined, resulting in sensitivity to even quite small deviations from the desired status. This sensitivity will result in a search for means of bringing the projects back on schedule through a combination of resource allocation and adjustment to project inflow. However, the preoccupation with completion goals often results in more emphasis being placed on resource allocation than on adjustment to the inflow and this will be assumed in the initial strategy.

The focus on the completion goal structure and close control with project progress is quite compatible with great attention to the competence level of the staff. The general completion centered strategy will, therefore, be tested in conjunction with a perception of the competence that quite accurately reflects the actual competence and a relatively slowly changing aspiration level, although the past performance will be given more weight than was the case in the competence

emphasizing strategy. The main difference is that when it comes to making the trade-off between the maintenance of long run competence and short run completion goal the greatest weight will be given the completion goal.

Six strategies will be tested initially, four in the major category concerned with the competence goal and two concerned with the completion goal. The details of each strategy are spelled out in the following pages together with a priori hypotheses about their relative effectiveness. For each strategy the actual simulation result will be shown and the behavior of the organization in response to the strategy will be explained.

An overview of the strategies is shown in Appendix B.

Strategy 3.1 - Emphasis on competence and willingness to make schedule changes, combined with close control of project progress and rapid adjustment to project inflow.

Hypothesis - High long term output and a stable work environment.

The above strategy is reflected in a lengthening of the time it takes to alter the managerial competence aspiration from 24 months in the initial run to 72 months. At the same time the weight of the managerial competence aspiration in

the formation of the operational competence goal has been raised to .8 from .5, and the weight of the perceived competence level lowered correspondingly to .2. With the increased emphasis on competence, the lag between the actual competence level and the perceived competence level has been reduced from 12 to 6 months.

The emphasis on the competence goal will lead management to react more strongly, as far as reallocation of manpower is concerned, to deviations from the goal than to deviations from the completion goal, as indicated in Table 3.1.

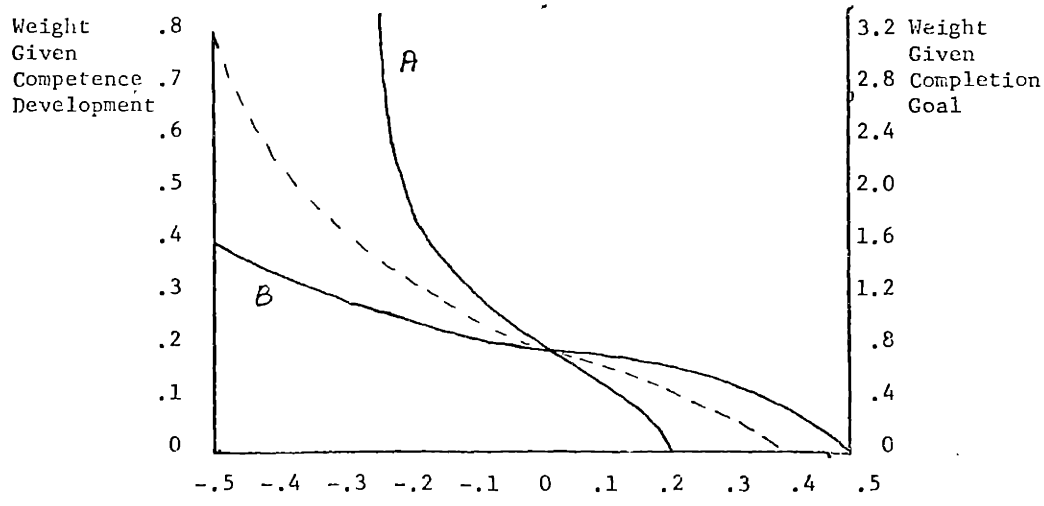


Table 3.1

Allocation of Staff Effort to Competence Development and Work Effort in Response to Deviations from Operational Goals

Curve A relates to the scale on the left, curve B to the scale on the right. The dotted line indicates the neutral strategy tested in Chapter 2.

The focus on competence leads management to a greater willingness to change the completion goals because the work pressure must be reduced. In all the competence centered strategies, the willingness to change the completion goal has been increased from 36 months to 18 months and the weight of the completion aspiration level reduced from .5 to .3 for the formation of the operational completion goal. Conversely the weight of the perceived completion rate has been increased from .5 to .7.

Having established reasonable consistency between the competence and the completion goal structures, alternative strategies placing different emphasis on project progress control and project acceptance policies in relation to the work pressure can be studied.

Strategy 3.1 will test a close project control, combined with rapid adjustment to project inflow in response to deviations from the operational competence goal and the desired project backlog. Tight project control is indicated in the

model by a change in the time to smoothe the completion rate and in the time to change perception of the project backlog from 6 to 4 and 6 to 3 months respectively. The implication is that when tight control procedures e.g., in the form of PERT or CPM are used, management has a more current idea about the efficiency of the staff. It may, therefore, consider a shorter time period on which to base its perception of the performance, and it will have a more accurate perception of what the project backlog really is.

The more rapid adjustment to the project acceptance is illustrated in Table 3.2.

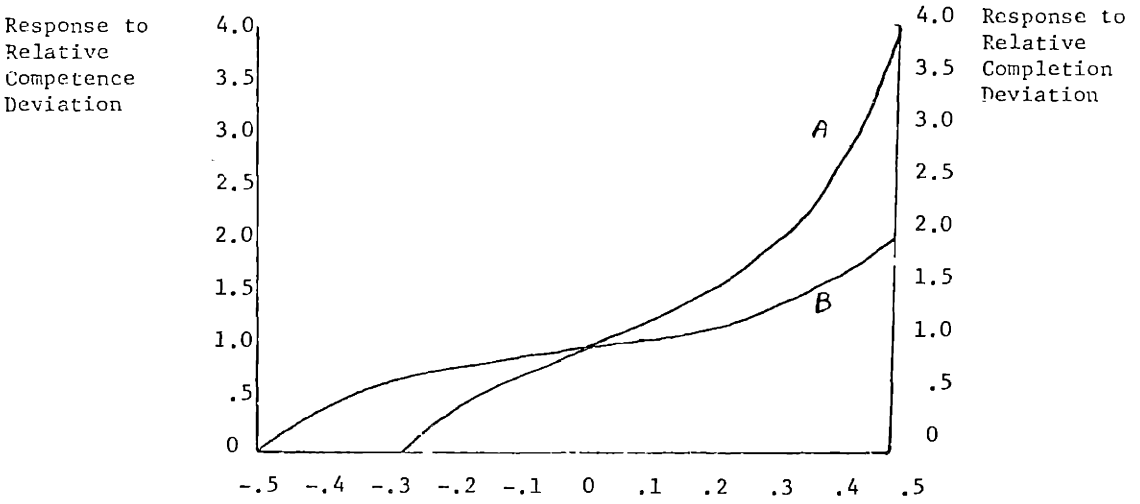


Table 3.2

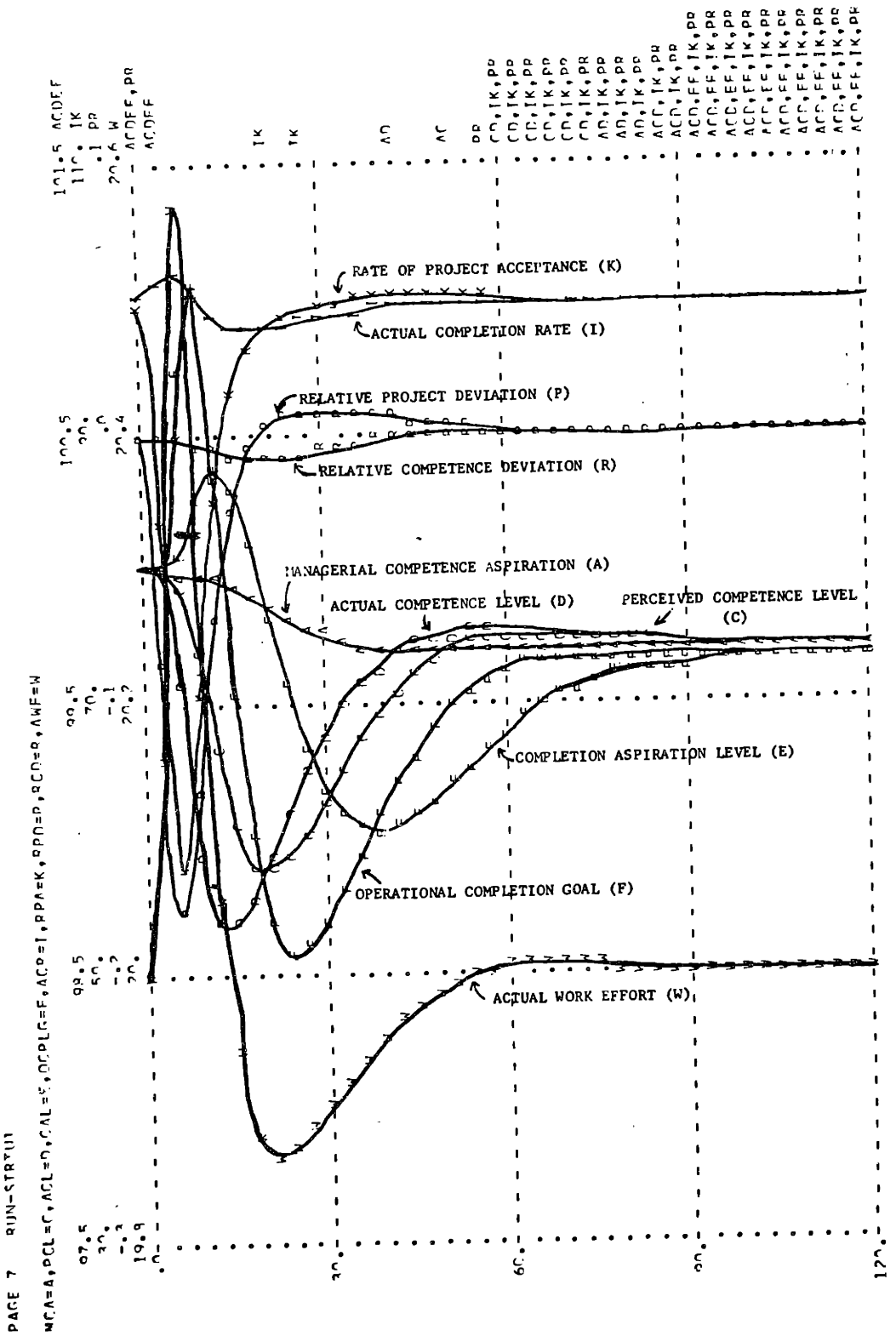
Adjustment to Project Acceptance
in Response to Deviations from Operational Goals

The more rapid adjustment is indicated in curve A. Curve B illustrates the response used in the simulation in Chapter 2. It is implied, for example, that when the deviation reaches a point 30% from what is desired, the inflow of new jobs will be stopped altogether, and on the other side, that when the organization is ahead of schedule, new projects will be accepted very rapidly.

The simulation results tested under the condition of one underestimation of 25% and a constant bias, i.e., underestimation of 10% of the work involved in the projects accepted are shown in Run STRTU1 and STRTB1 respectively.

The strategy is considerably more effective than the neutral strategy of Chapter 2, resulting in accumulated output of 11, 942 work units in the case of STRTU1 and 11,902 work units in the case of STRTB1. The strategy is effective in maintaining the long term competence which is improved from 93.3 to 99.7 and 82.1 to 98.7 respectively. Even the constant pressure of a 10% bias has not been able to seriously affect the competence, because the inflow of jobs accepted is reduced rapidly enough to offset the bias, and because the staff is not reallocated to work effort to a large enough extent to damage the competence level in the long run.

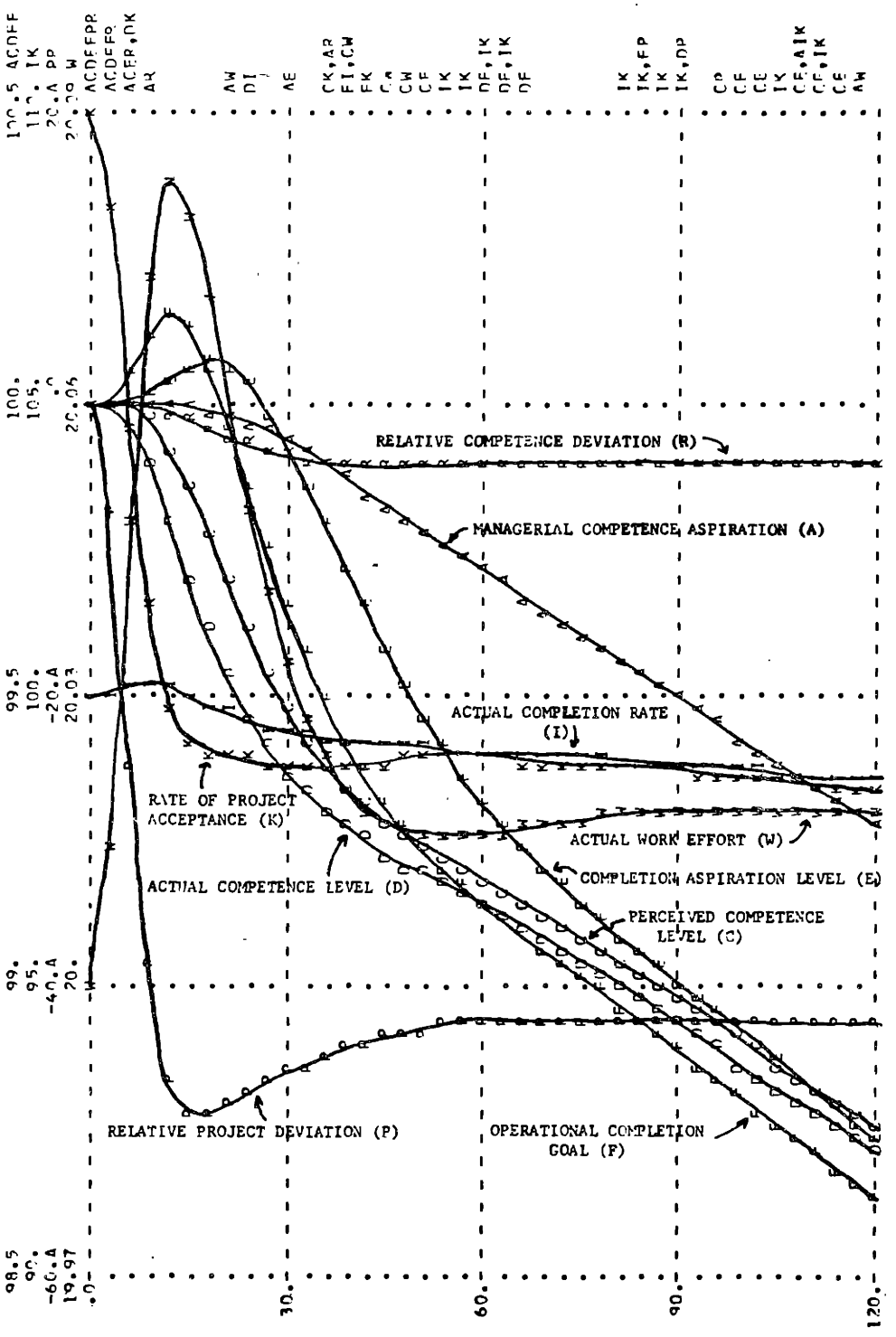
SIMULATION RUN - STRTU1



PAGE 7 RUN-STRTU1

WCA=A,PCL=C,ACL=D,GAL=E,OCPLG=F,ACP=I,PPA=K,PPD=P,PCD=R,AWE=W

SIMULATION RUN - STRTB1



PAGE 7 RUN-STRTB1

MCA=A,PCL=C,ACL=D,CAL=E,OCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

Strategy 3.2 - Emphasis on competence and willingness to make schedule changes, combined with close control of project progress and slow adjustment to project inflow.

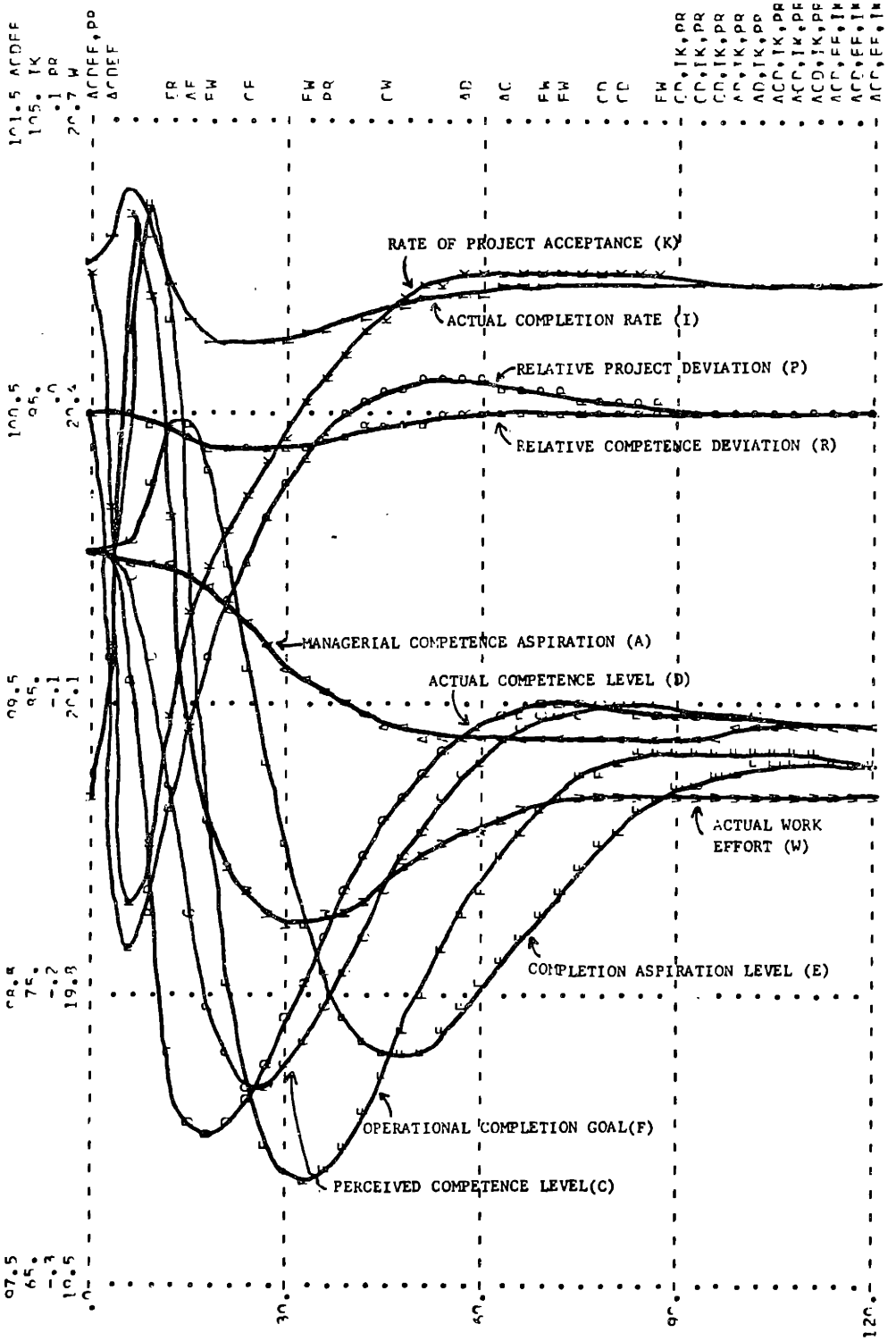
Hypothesis - Lower long term output and a more unstable work environment than in strategy 3.1.

Strategy 3.2 differs from strategy 3.1 only by the slower adjustment to project inflow in response to the deviation from competence and completion goals. The response is illustrated by curve B in Table 3.2.

The results of the simulation - again testing for both one - shot underestimation and continuous bias - are shown in RUN-STRTU2 and RUN-STRTB2.

As predicted, the long run output is lower than in strategy 3.1 - 11,885 and 11,815 respectively, and the long term competence level is also lower - 99.4 and 97.5 respectively. The reason is, quite clearly, that when the pressure is allowed to persist in the system for a longer period, the adverse effect on the competence level is being sustained over a longer period of time. The managerial competence aspiration is, therefore, also under pressure and management eventually settles for a lower

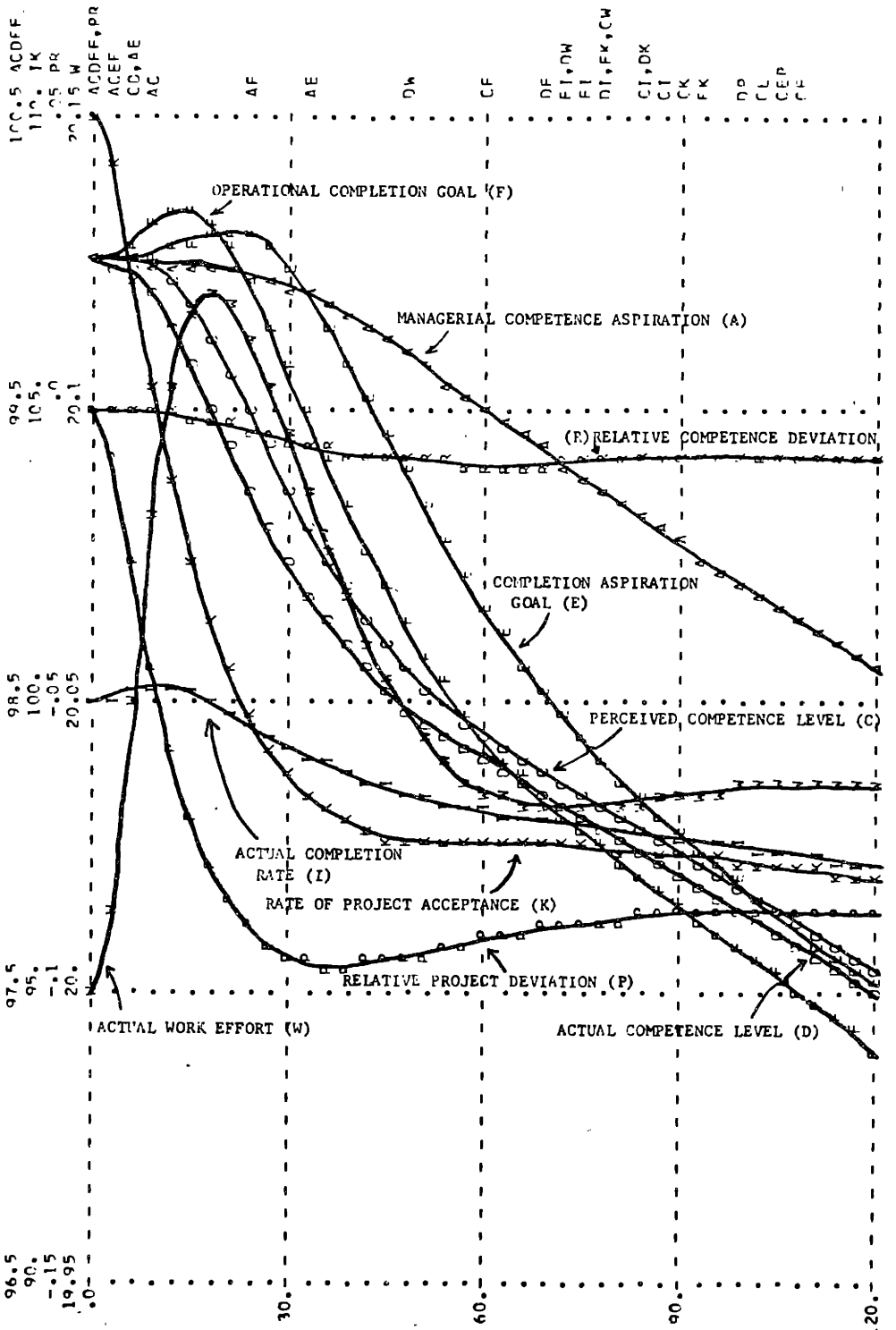
SIMULATION RUN - STRTU2



PAGE 11 RUN-STRTU2

MRA=A,PRL=C,ARL=D,GAL=F,ACC=I,PRA=K,PRD=P,RCD=R,AWF=W

SIMULATION RUN - STRTB2



PAGE 11 RUN-STRTB2

MCA=A,PCL=C,ACL=D,CAL=E,OCPL=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

aspiration level than it would otherwise have done. The adverse effects are more noticeable in the case of bias than when the underestimation is a one-shot affair.

Strategy 3.3 - Emphasis on competence and willingness to make schedule changes, combined with loose control of project progress and rapid adjustment to project inflow.

Hypothesis - Long term output between that of strategy 3.1 and 3.2 and a more unstable work environment than strategy 3.1.

Strategy 3.3 is identical to strategy 3.1 with the exception that management pays little attention to formal project control. The perception of the actual project backlog is not very accurate and neither is the perception of the actual completion rate. This is illustrated by a change in the time to change the perception of the project backlog from 3 to 12 months and a doubling of the time to smoothe the completion rate from 4 to 8 months.

The result of the simulation run is that the ouput is 11,950 and 11,902 work units for RUN STRTU3 and RUN STRTB3 respectively. The actual competence level at the end of the 10 year period is at 99.8 and 98.7 respectively.

Contrary to the prediction, the result is slightly better than for strategy 3.1. Can it really be true that loose project control is better than or just as good as tight project control?

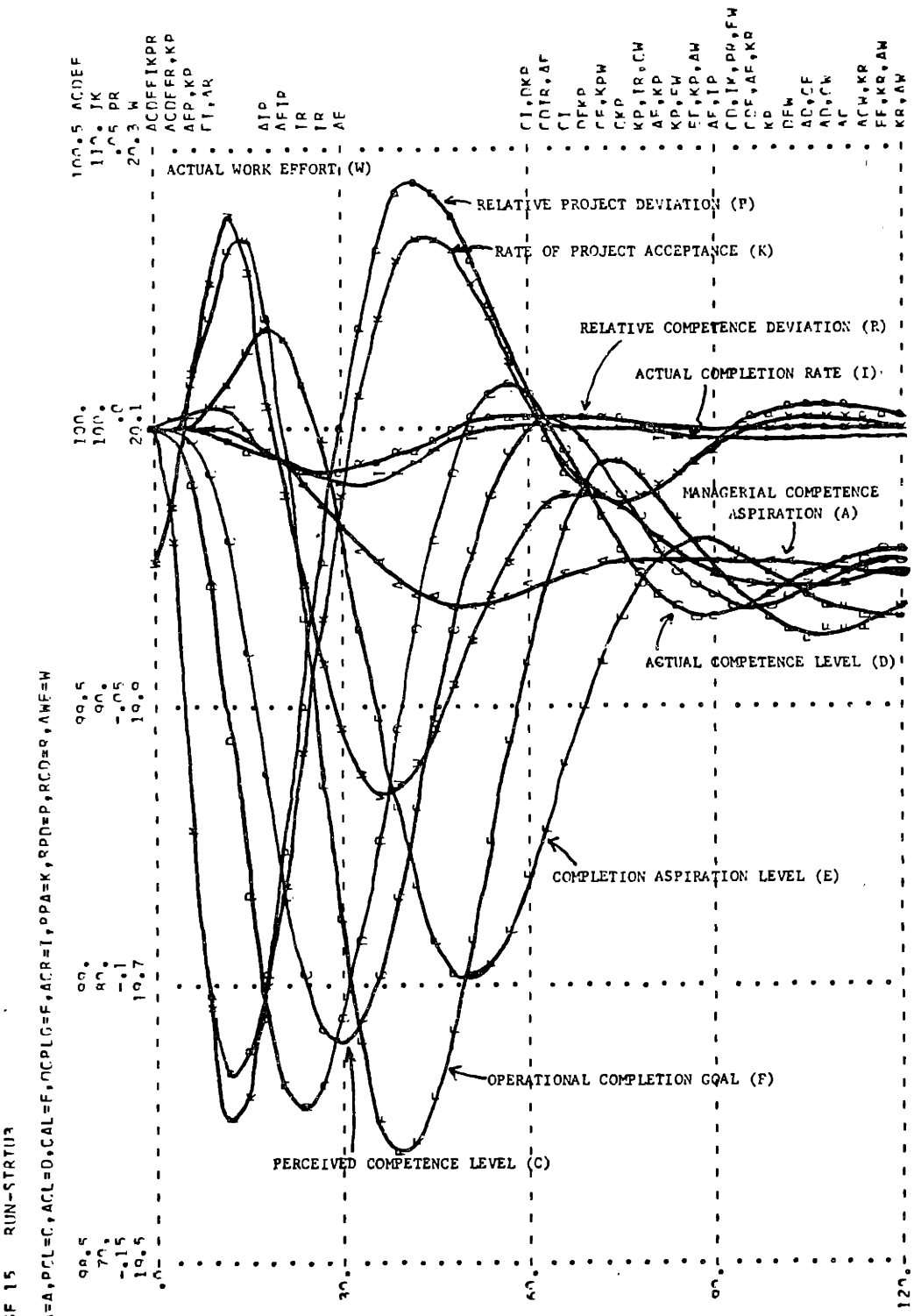
If one looks carefully at the plots of the runs, and considers the fact that the scales are slightly different in the two sets of runs, it appears that the loose control has the effect of also smoothing the perception of project progress. The Perceived Project Deviation does not become as great as before. The result is less reallocation of effort and the actual competence level is not affected as much as before. The pressure is taken out of the system by a gradual adjustment of project inflow and by adjustments to due dates.

Strategy 3.4 - Emphasis on competence and willingness to make changes to schedules, combined with loose control of project progress and slow adjustment to project inflow.

Hypothesis - Lower long term output and greater instability than any of the previous three strategies.

Strategy 3.4 combines the slow adjustment to project inflow of strategy 3.2 with the loose control of project progress of

SIMULATION RUN - STRTU3



PAGE 15 RUN-STRTU3

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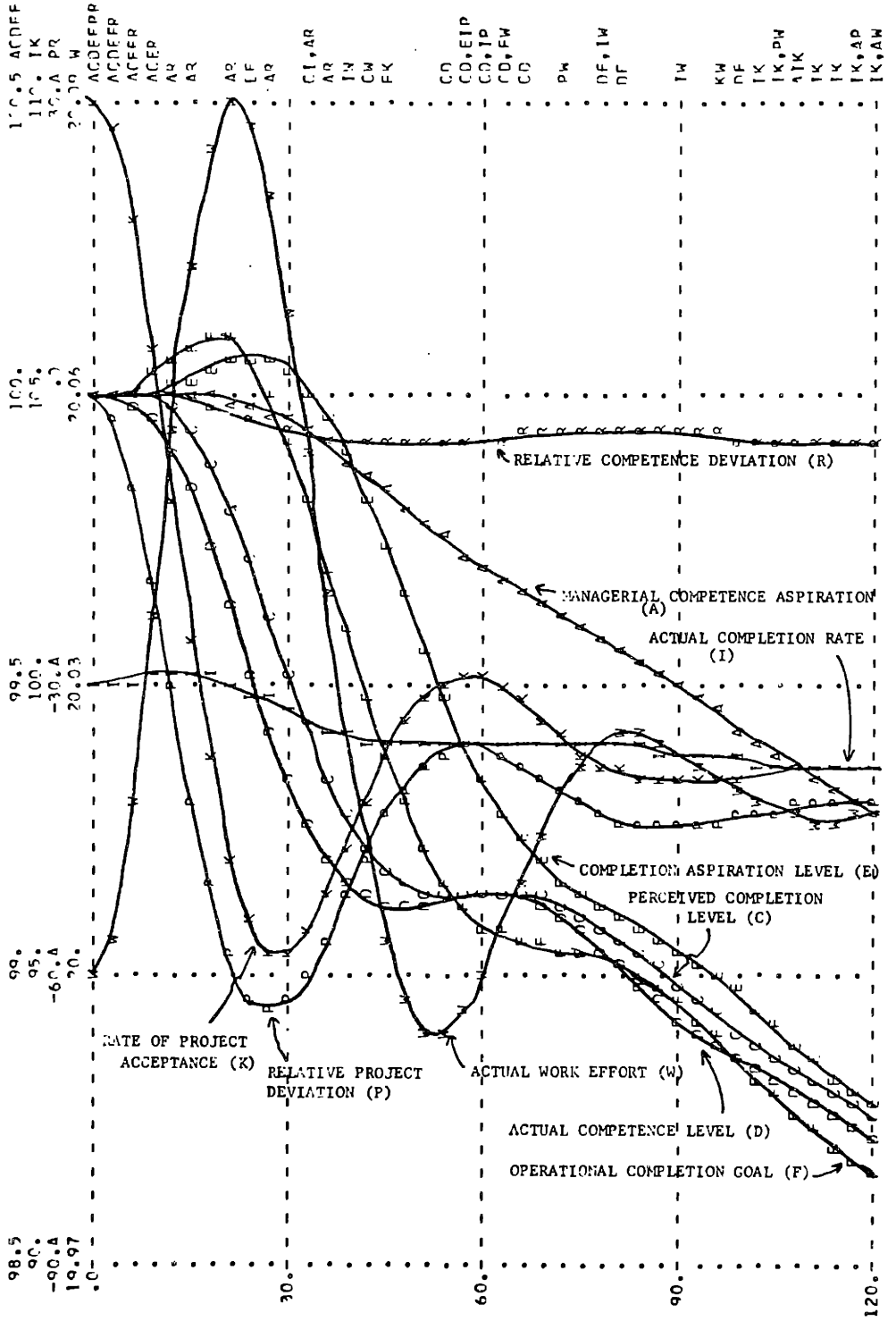
SIMULATION RUN - STRTB3



PAGE 15 RUN-STRTB3

MCA=A,PCL=C,ACL=D,CAL=E,OCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

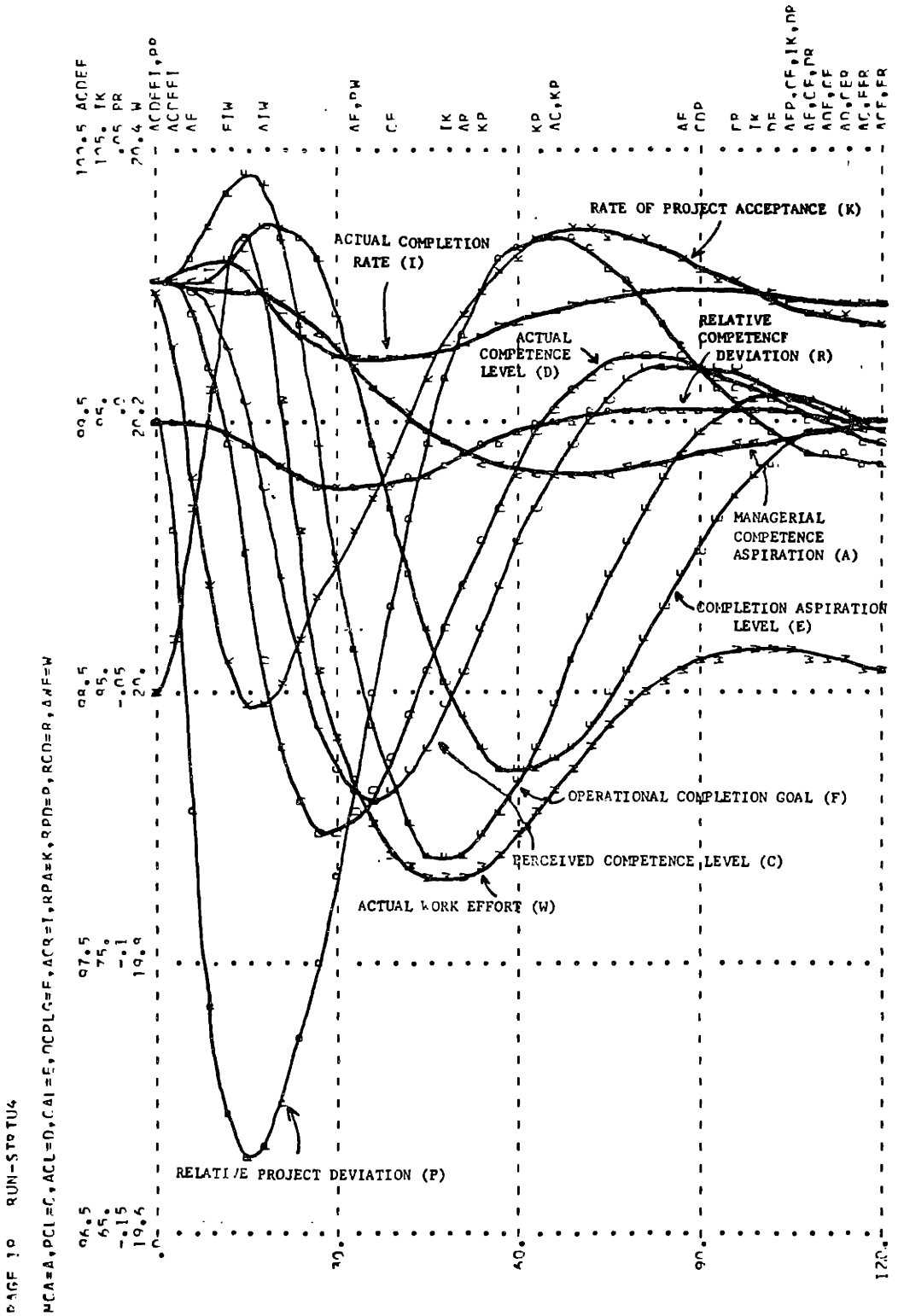
strategy 3.3. Curve B of Table 3.2 shows the adjustment to project inflow. The time to change perception of project backlog is 12 months, and the time to smoothe completion rate is 8 months.

The result of the simulation runs RUN STRTU4 and RUN STRTB4 are total outputs of 11,892 and 11,805 work units, respectively, and an actual competence level at the end of the 10 years of 99.4 and 97.5, respectively.

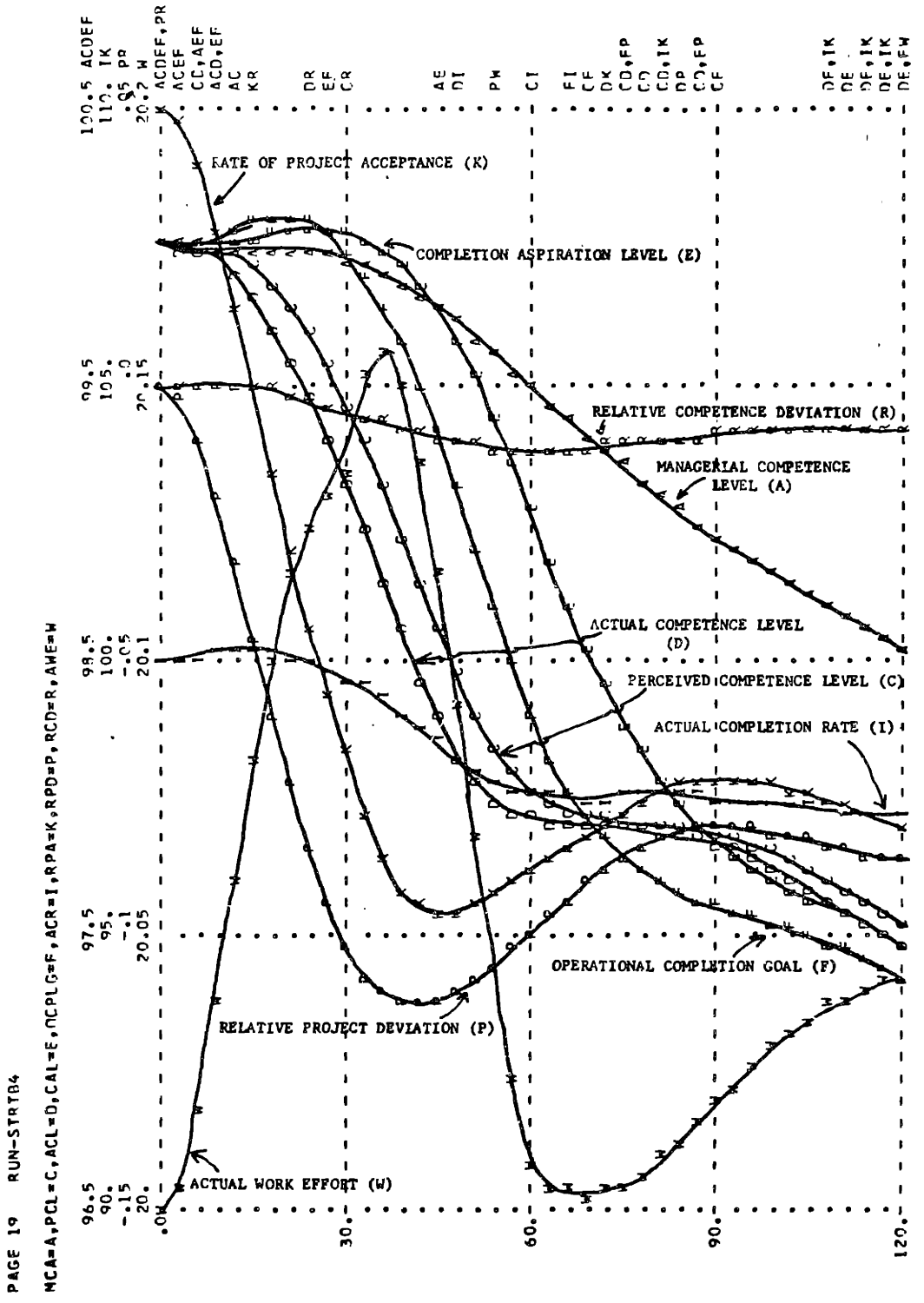
As in the case of strategy 3.3 this is contrary to the initial prediction. The results are quite compatible to the results obtained in strategy 3.2 and it appears again that the tightness of the control of project progress does very little for the overall performance, as long as the competence level is maintained.

The effect of the loose control is to smoothe the perception of the actual backlog and therefore moderate the reaction in terms of reallocation of effort. The pressure is taken out of the organization through adjustment to project inflow and adjustments to schedules. The system stability is therefore quite similar to the close control strategy as far as the magnitude of the deviation is concerned. It takes a little longer, however, for the system to find a new balance.

SIMULATION RUN - STRTU4



SIMULATION RUN - STRTB4



PAGE 19 RUN-STRTB4

MCA=A,PCL=C,ACL=D,CAL=E,OCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

Strategy 3.5 - Emphasis on completion goal, combined with reluctance to change the managerial competence aspiration and slow adjustment to project inflow.

Hypothesis - Lower long term performance and greater instability than any of the previous strategies.

The strategy focusses the attention on the project completion goals. Management is very reluctant to change the completion goal. This is indicated by a change in the willingness to change the completion goal from 36 to 72 months and an increased weight from .5 to .7 attached to the completion aspiration level over the perceived completion rate for the formation of the operational completion goal. There is a strict control with project progress illustrated by the time to smoothe the completion rate set at 4 months, compared to 6 months in the neutral strategy. The time to change perception of project backlog is set at 3 months compared to 6 months in the neutral strategy.

At the same time as management focusses on the completion goal, it will have a more accurate perception of the competence level - obtained through tighter project control - and this is reflected in a shortening of the time to change the perception of the competence level from 12 to 6 months and an increased reluctance to alter the managerial competence aspiration from

24 to 48 months. The perceived competence level is given equal weight as the managerial competence aspiration in the formation of the operational competence goal.

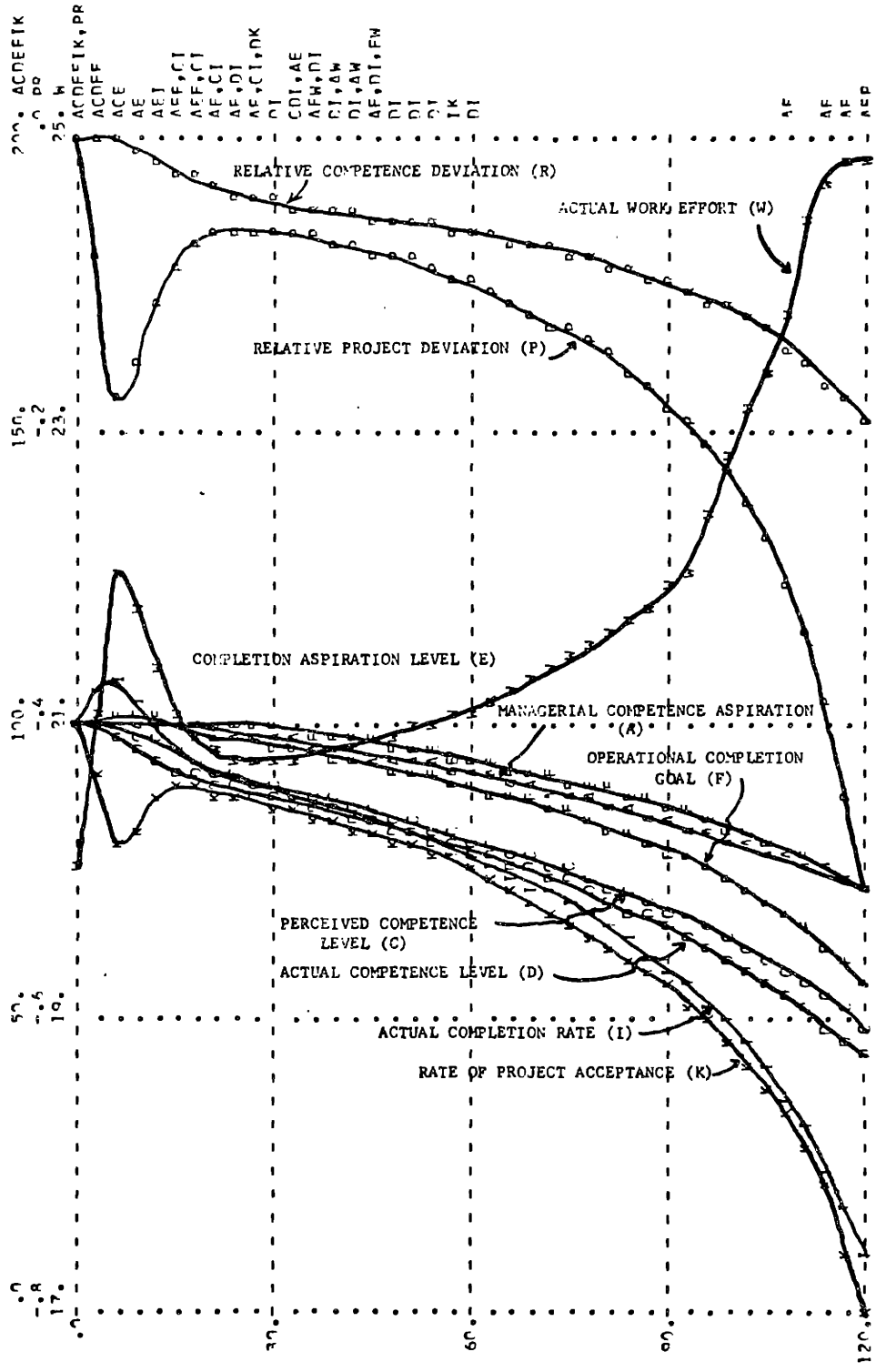
The emphasis on the completion goal is further underscored in the allocation of resource policies in response to deviation from the Desired Project Backlog and the Operational Competence Goal. Table 3.1 illustrates the allocation policy. This time, however, curve A refers to the allocation to work effort (the right hand side of the graph) and curve B refers to the allocation to competence development (the left hand side of the graph).

The completion centred strategy is tested with a slow reaction to project acceptance as illustrated by curve B of Table 3.2.

The results - shown in RUN STRTU5 and RUN STRTB5 - are a total output of 8688 and 7900 work units respectively and competence levels of 43.4 and 31.4.

Given an environment with rapidly changing technology and techniques, the model indicated disastrous results from focussing too strongly on short term completion goal compared with competence maintenance. Even the fact that the strategy showed a clearer awareness of the actual competence

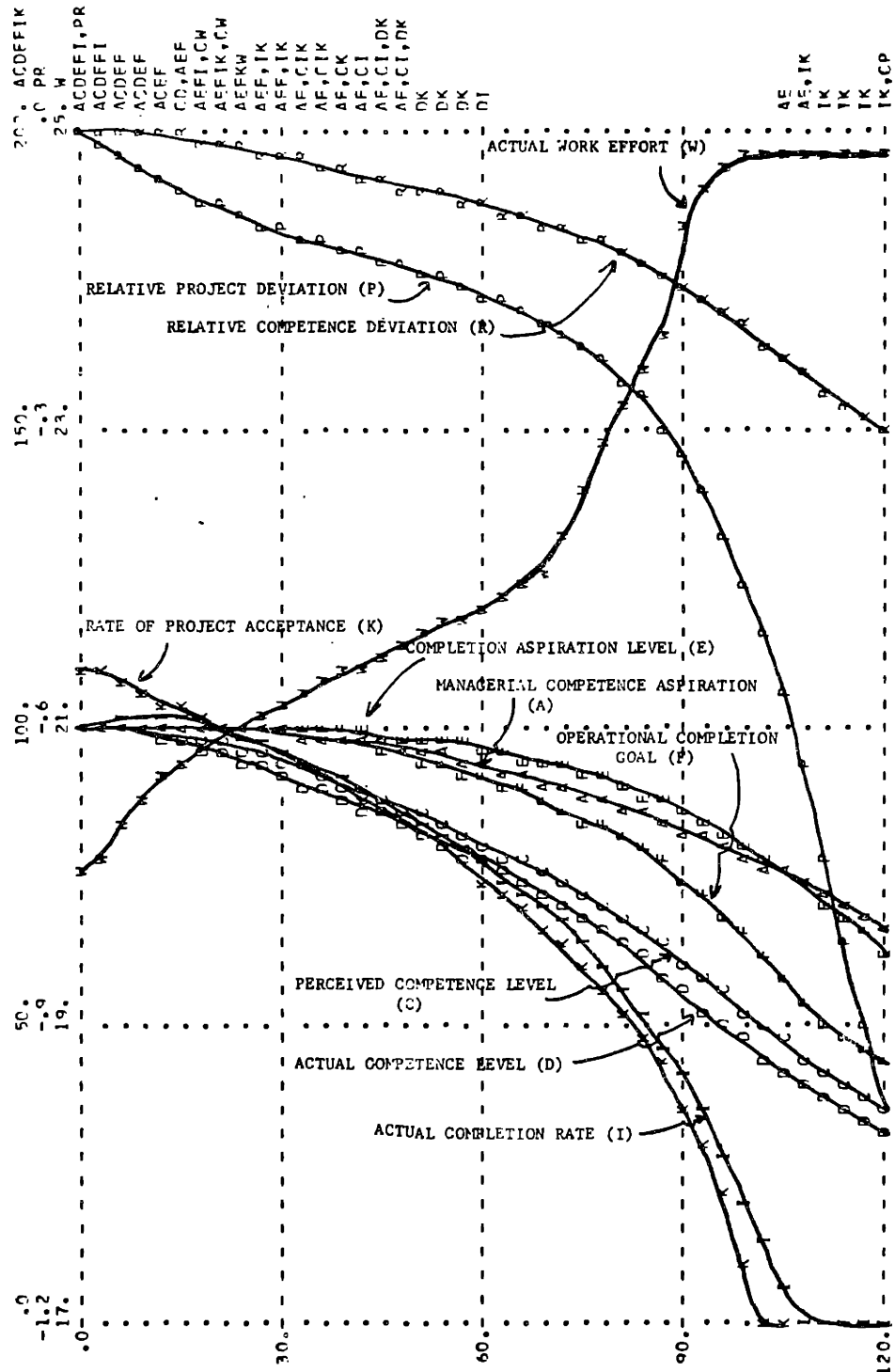
SIMULATION RUN - STRTU5



PAGE 23 RUN-STRTU5

MCA=A,PRL=C,ACL=D,CAL=E,OCPLG=F,ACP=I,RPA=K,RPO=P,PCO=E,AWE=W

SIMULATION RUN - STRTB5



PAGE 23 RUN-STRTB5

MCA=4,PCL=C,ACL=D,CAL=E,OCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

level than the initial neutral strategy, was insufficient to sustain high long term competence.

The high and rigid competence goal leads to over-commitment which continuously forces the staff towards more work effort and less competence development. Gradually, it becomes more difficult to regain the competence and when the work pressure is maintained the system can only collapse.

Strategy 3.6 - Emphasis on completion goal combined with reluctance to change the managerial competence aspiration level and rapid adjustment to project inflow.

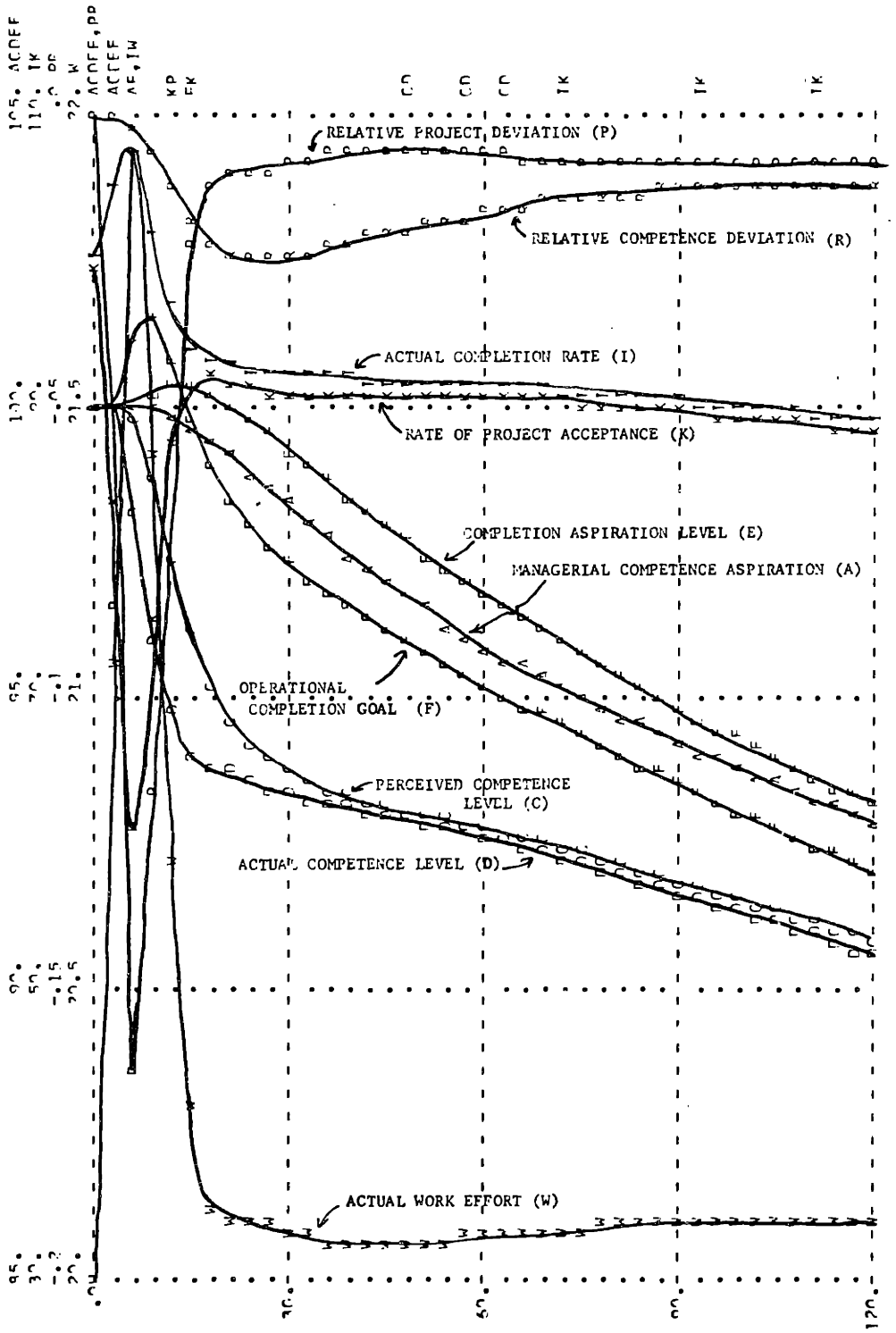
Hypothesis - Long term result between that of run 3.4 and 3.5 and more stability than in 3.4 and 3.5.

The only difference between strategy 3.6 and 3.5 is that the project acceptance rate is being adjusted according to curve A of Table 3.2 rather than curve B.

The results of RUN STRTU6 and RUN STRTB6 are total ouputs of 11,103 and 10,385 work units respectively and competence levels of 90.6 and 71.5 respectively, which is as predicted.

The fact that the adjustment to project inflow is greater in response to deviations from the goals than was the case in 3.5, relieves some of the work pressure faster and the competence level does not deteriorate as rapidly as was the case in 3.5.

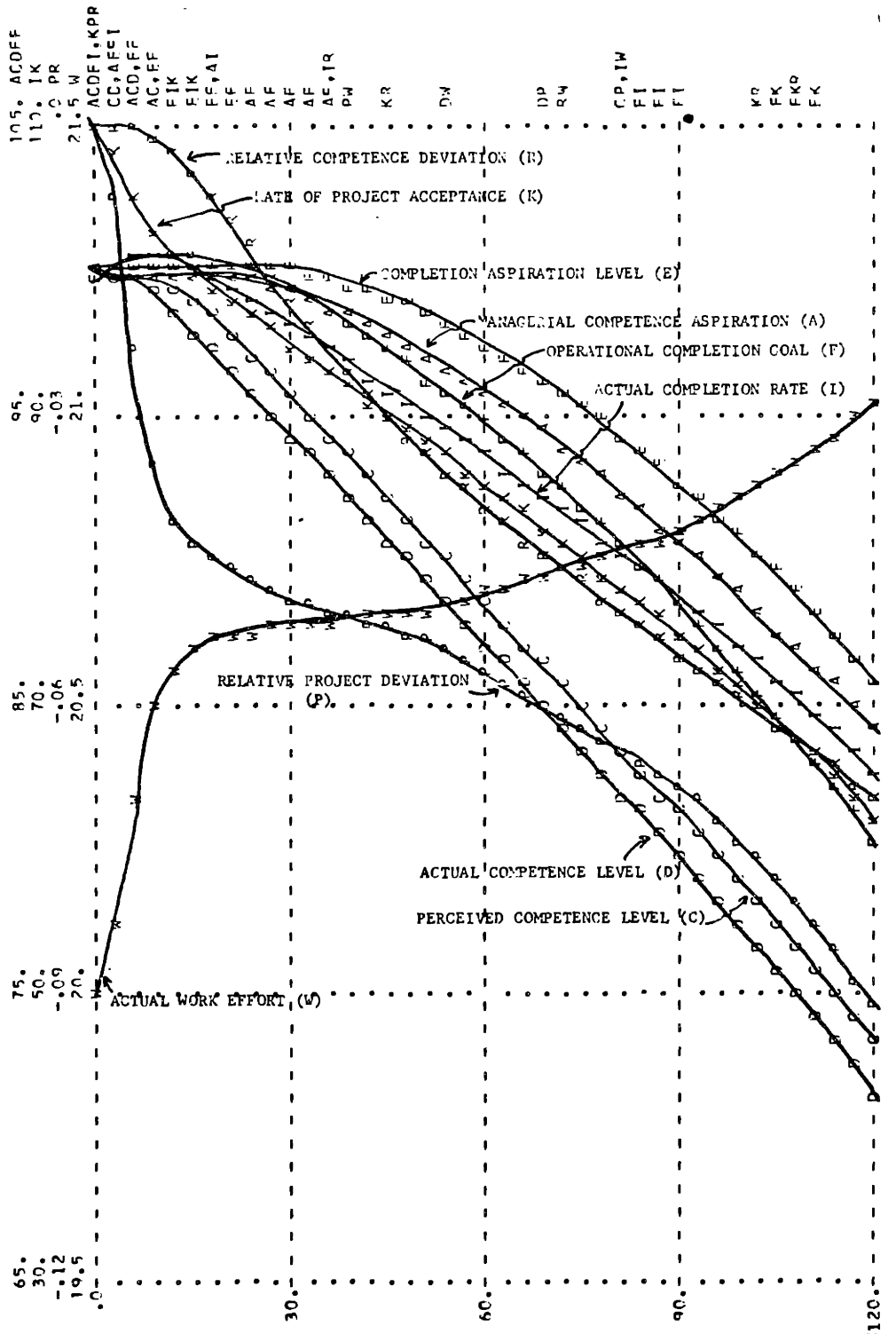
SIMULATION RUN - STRTU6



PAGE 27 RUN-STRTU6

MCA=A,PCL=C,ACL=D,FAL=E,OCPI=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

SIMULATION RUN - STRTB6



PAGE 27 RUN-STRTB6

MCA=A,PCL=C,ACL=D,CAL=E,MCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

3.7 SUMMARY OF THE RESULT OF THE 6 TESTED STRATEGIES

The first implication of the simulation results is that the competence centred strategies are superior to completion centred strategies. The second main implication is that the most effective managerial leverage point in alleviating work pressure is adjustment to the project inflow and adjustment to schedule where possible.

The results are summarized in Appendix C.

The most surprising outcome was that the control of project progress is insignificant, at least within a very wide range, as a determinant of long term behavior as long as the competence goal is maintained. The implications of this finding will be elaborated in Chapter 5.

It may be proper at this point to briefly restate the model assumptions and discuss what effect they might have had on the results just described. The major deviations from an actual organization are that the model does not allow for additions or departures of staff, and that the effect of client reaction to the quality and timeliness of the product or service provided has not been considered. These factors could be added to the model formulation to allow a more

systematic evaluation of the effect of these factors on the validity of the conclusion made above. For the moment, however, the evaluation must be made on the basis of a purely qualitative analysis of the likely impact of these factors on the results obtained.

The personnel issue involves the effect of hiring and voluntary and involuntary departures from the organization. One point here is that while the effect of a person leaving is felt immediately, the effect of adding a person is usually felt only after some delay because the new person requires a period of time for orientation to the new situation. Hiring as a means of relieving work pressure is, therefore, only effective with some delay and if used as the only method, the effect of the work pressure may damage the competence level in the long run. Another point to consider is that the Managerial Competence Aspiration is the guide to hiring in most cases, and, in addition, influences the voluntary departures. It must be expected that if the Managerial Competence Aspiration has been allowed to fall because of sustained work pressure, management will look for staff that meet its current aspiration level. If management yields to the pressure by slowly lowering its aspiration level, it is most likely that the personnel with

high personal standards decide to leave the organization thereby accelerating the decline in the overall organizational competence. For these reasons it seems that the model in its present simplified structure still yields useful results in testing alternative strategies, although it would be preferable to specifically incorporate this aspect in the model. The Managerial Competence Aspiration is the crucial factor, however, and unless management pays specific attention to it, it will decline by allowing the work pressure to build up.

The issue of the effect of the quality on the inflow of new projects is not too different. It must be assumed that the greater the quality, the greater the pressure on the organization to take on more projects, because more people will want the organization to serve them. Unless management is aware of the long term adverse effect of an excessive workload on the competence level, it may yield to the pressure. This pressure will not be relieved until the quality of the output reaches a low enough level to balance the inflow of jobs to the competence level. This is clearly not a desirable mode of operation, since a more attractive alternative for balancing the workload to the staff's capabilities is through the price

mechanism. High quality performance can be sustained by regulating the inflow through high prices.

One may cautiously conclude that the simulation results are sufficiently valid to take the conclusions made above seriously. The general direction of the findings made will be followed up in Chapter 4 in an effort to further highlight the main managerial leverage points for dealing constructively with work pressure.

CHAPTER 4

TOWARD IMPROVED PROJECT PERFORMANCE

The simulation runs in Chapter 3 pointed to the elements of the model that are most significant for the long term performance of the project organization. It is apparent that in order to maintain long term productivity, the highest priority must be given the competence goal structure, because the effectiveness of the work effort expended on projects depends on the competence level. Given the fact that work pressure is virtually inevitable in a project type organization, management must look for means of relieving the pressure without jeopardizing the competence. The greatest leverage has been found to be the adjustment to project inflow as demonstrated by strategies 3.1 and 3.3.

It was demonstrated by strategies 3.2 and 3.4 that if the adjustment to the project inflow in the face of work pressure was only slow, the work pressure would eventually detract manpower from competence-maintaining activities toward actual work activities. The competence level would gradually decline and management would slowly lower its aspiration level to

correspond more closely with the perceived competence level. Since there are no forces at play that will automatically raise management's competence aspiration level, long term deterioration of competence is a likely outcome. It may well be that some project organizations that must cope with competition in the marketplace will be under more pressure to stay competent, but even in such cases the competence aspiration level is the cornerstone to excellence. Organizational project departments such as Research and Development departments and Information Systems departments can survive physically for a long time after their usefulness to the organization has ceased, because the competence has deteriorated too far.

It may be said that it is the reallocation of effort away from competence maintaining activities that causes the main problem. An obvious - if not practicable - solution is, therefore, to simply maintain the necessary allocation to competence development regardless of the work pressure.

Strategy 4.1 - Emphasis on the competence goal. No reallocation of staff in the face of work pressure.

This strategy is tested with the parameters used in Strategy 3.3, the only change being a change to Table 3.1 as follows:

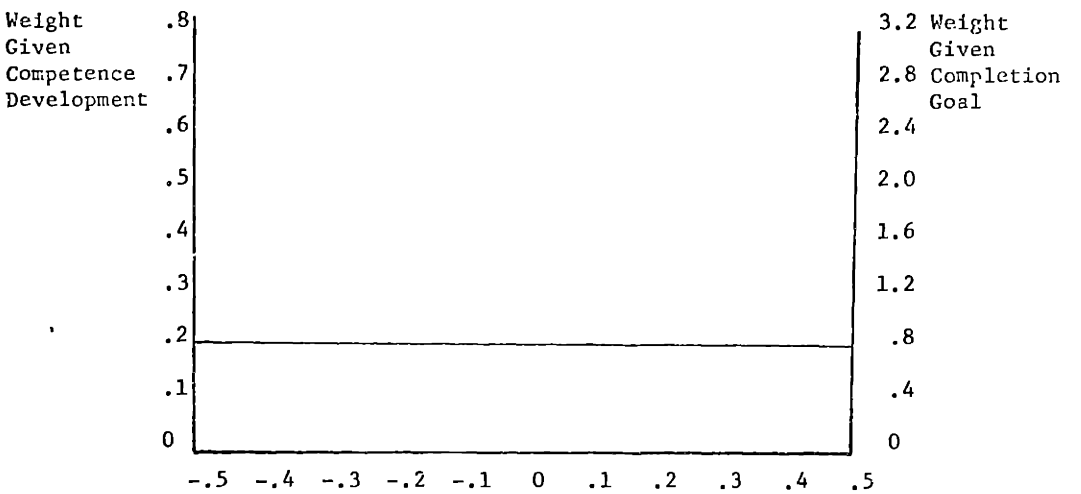


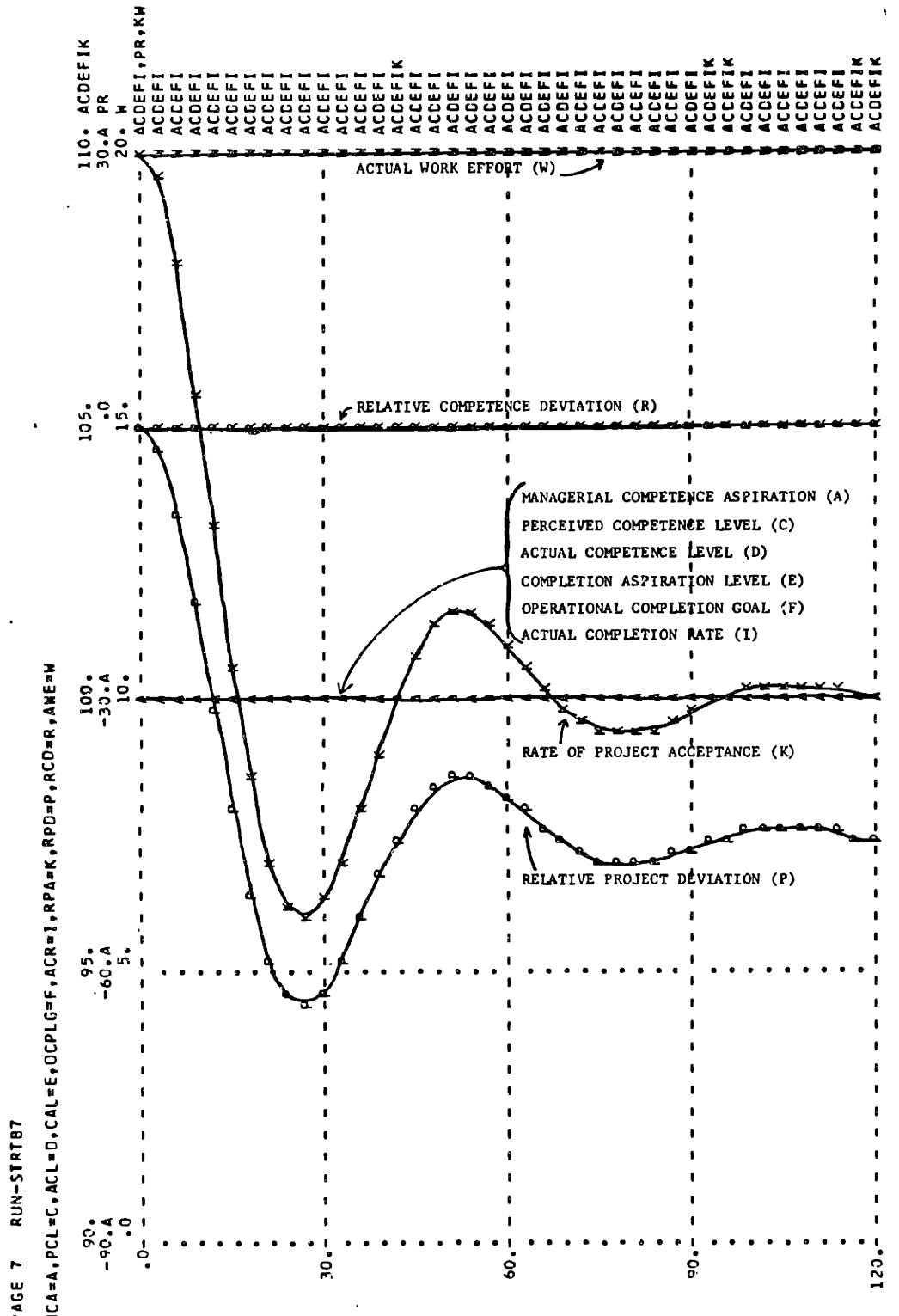
Table 4.1

Adjustment to Project Acceptance in Response to Deviation from Operational Goals

Strategy 4.1 is tested under the assumption of a 10% continuous underestimation of the accepted projects.

The result, shown in RUN STRTB7, is a total output of 12,000 work units and a constant competence level of 100, which is the best result obtained yet. As is the case for all the strategies when tested under the permanent underestimation condition, the Relative Project Deviation is always negative,

SIMULATION RUN - STRTB7



but the difference is kept at a relatively low level through adjustments to the project acceptance rate.

While strategy 4.1 has clearly shown the best results so far under our simplified assumptions, it is not very realistic. No management will be able to ignore delays in promised projects without reacting to some degree by reallocating the staff, at least in the short run. Consciously and rigidly maintaining a high aspiration level therefore becomes important.

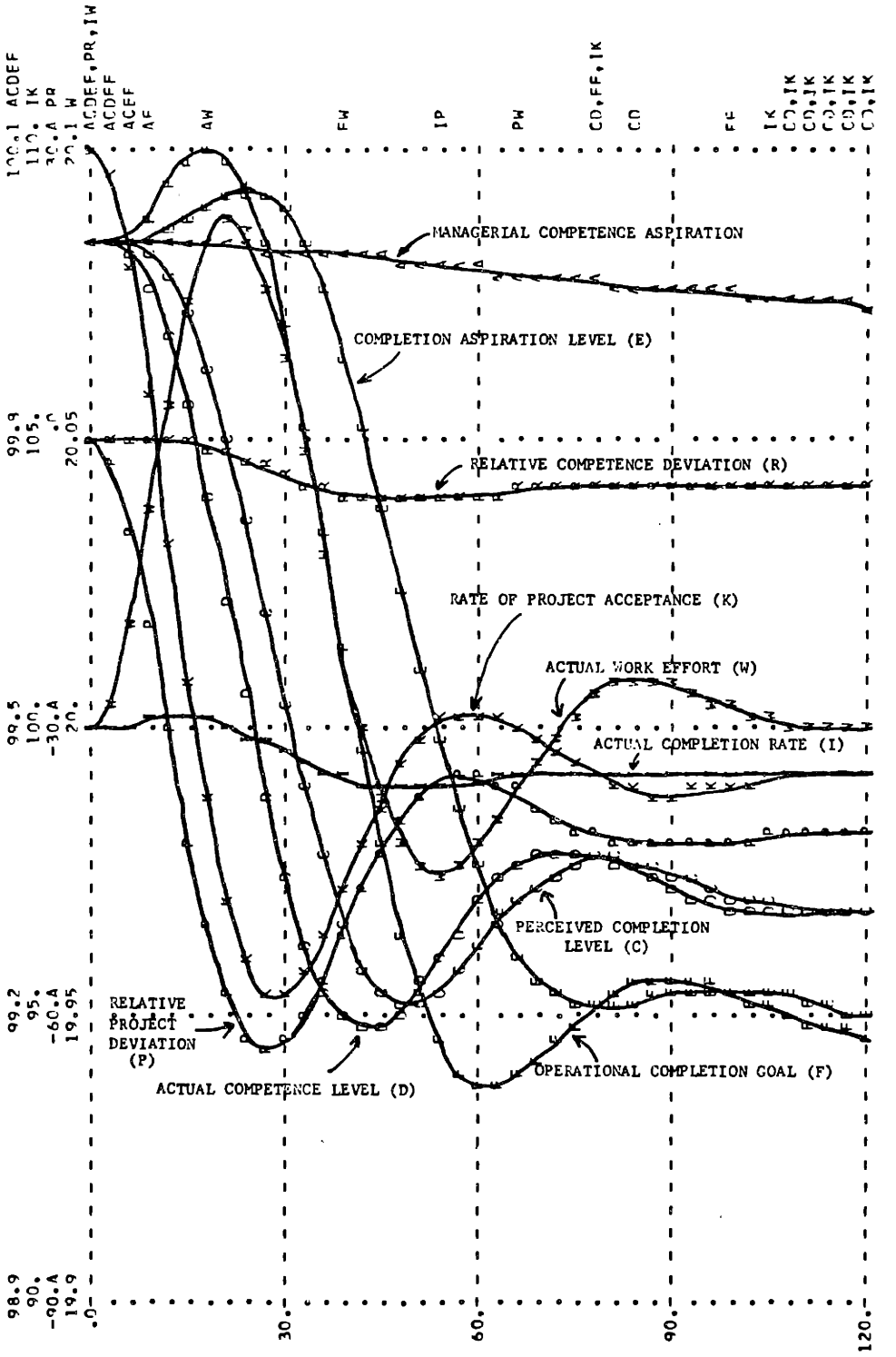
Strategy 4.2 - Emphasis on competence goal and total unwillingness to compromise the competence aspiration level, combined with rapid adjustment to project acceptance.

Strategy 4.2 is identical to strategy 3.3 except that the willingness to change the managerial competence aspiration has been extended from 72 months to almost infinity (1000 months).

The result, shown in RUN STRTB8, is 11,925 work units and a competence level of 99.3 almost identical to the original aspiration level, despite the fact that reallocation of staff in response to work pressure was taking place.

Strategies 4.1 and 4.2 have served to strengthen the conclusions arrived at in Chapter 3, pointing to the maintenance of a high Managerial Competence Aspiration as the most crucial concern of the project manager, if he wishes to sustain long term high performance.

SIMULATION RUN - STRTB8



PAGE 35 RUN-STRTB8

MCA=A,PCL=C,ACL=D,CAL=E,OCPLG=F,ACR=I,RPA=K,RPD=P,RCD=R,AWE=W

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

The simulation model of the goal structure of project organizations has been formulated under some simplified assumptions. First of all the three main short term goals of schedule, cost and quality and the long term goal of staff competence have been reduced to two main goal structures, i.e., a competence goal structure encompassing the long term staff competence and the quality aspects, and the completion goal encompassing cost and schedule. Secondly, it has been assumed that the inflow of new projects is solely under the control of the organization. Thirdly, it has been assumed that the staff is constant, and if there is any turnover of people the entering person is at the same competence level as the departing person.

The simplification has been made so that the effect of the relatively pure managerial strategies could be evaluated. The managerial characteristics have been reflected in: the goal formation over time, the effect of the clarity of the goals, the managerial reaction in terms of allocation of staff between the two goal activities, and the effect of the closeness or looseness of the control procedures employed in monitoring

the two goal-seeking activities. No specific methods have been discussed in relation to any of these different managerial activities. The model has been designed to provide insights into the main leverage points for successful long term project performance.

The simulation runs have demonstrated that management must be highly committed to the competence goals in order to sustain high competence in the face of work pressure brought about by the many factors pulling toward underestimating the work load. The managerial commitment may be tested in varying degrees, depending on the possibilities of releasing the work pressure by other means than reallocation of staff from competence maintaining activities to direct work effort. The simulation runs demonstrated that the long term results, given the same degree of commitment to the competence goal, improved as the acceptance of new projects was adjusted in response to work pressure. An alternative to releasing the pressure through adjustment to the project inflow was to decouple the competence goal structure completely from the completion goal structure by total unwillingness to alter the allocation of the staff that maintains the competence aspiration level.

In the light of these findings, it is less surprising to find that the tightness or looseness of the project progress control is less important for long term success. While this conclusion, on the surface, is counter-intuitive, it is clear that tight control in itself has no influence on relieving work pressure. On the contrary, it may be a significant pressure on management to reallocate the staff, thereby reducing the competence level. This explains why runs 3.3 and 3.4 showed the same long term results as 3.1 and 3.2, respectively. With loose control procedures the deviation from the schedule is perceived in a smoother fashion, resulting in less reallocation and hence with less effect on the competence level.

The simulation did demonstrate, however, that the organization would return to a balanced position more quickly as the project control tightens, but at a slightly lower competence level.

Because of the simplified assumptions made in the model formulation, caution must be exercised in moving from these model results to drawing definitive conclusions about the implications for the management of project organization. Based on the discussion of model validity carried out throughout the development and testing of the model, the

results cannot be ignored.

It is safe to say that maintaining a high aspiration level is absolutely essential. In an environment where innovations are made at a rapid rate over a wide front, management must allocate a large part of its own and staff time to following the developments in the relevant fields. A large portion of its time must go into reading of journals and other relevant up-to-date literature, attend conferences and seminars and actively seek out and motivate people to master the relevant state of the art. Management must spend a considerable amount of time consulting with and counseling the staff to know what sort of training and education is needed, and find ways, together with the staff, whereby the necessary knowledge and skills may be acquired. In the light of the required emphasis on competence, it was found that reallocation in response to work pressure was detrimental to long term success. Adjustment to the schedules and the inflow of new projects, therefore, become the major means of relieving work pressure, if it builds up. By expanding the scope of the model, the use of hiring new staff can also be investigated as a means of relieving work pressure.

Instead of finding ways of relieving work pressure, it would obviously be preferable to prevent it from building up in the first place. For this purpose, accurate estimates of the accepted workload are needed. The main difficulty of project management lies in this general area, and it is in this context that the degree of tightness of project control must be discussed.

On the one hand, there is a requirement that the estimate of the project workload be reasonably accurate and, on the other hand, the conclusion that tight control may generate erratic managerial behavior. The two sides are reconcilable, however, to the extent that the work on a project may be broken down into relatively clearly defined subtasks as part of the planning process, and that the actual time spent on each subtask may be recorded. This data may provide a useful base for estimating the incoming projects, but need not be processed on a continuous basis. The pressure-generating effort of frequent reporting of data with a high noise content can therefore be avoided.

It may be argued that deadlines have a motivating effect on the staff. On the other hand, it may be said that if dates take on too much significance, quality in physical terms as well as in terms of documentation, training and preparation of the clients for implementation may be sacrificed. The work that should have been done before

delivery must then be done afterward. In other words, the result may be to create a distinction between project delivery and project completion and proceed as if the former were the goal in the execution of the project.

For many projects, as in the case of many Management Information Systems and Research and Development projects, the schedule is of minor importance. It may be true that the cost of a project, and therefore the profitability of it, is closely related to the time it takes to develop it. Looking at the long term profitability of applying human resources rather than the profitability of the individual project, it is likely that it would pay to take the loss of an override on one project in order to increase the chances of making a profit - through a competent, confident staff - on the next project. Management will benefit in the long run from making the schedules flexible while focussing on the staff competence as has been demonstrated by the simulation runs.

The final critical area for management action is in the adjustment to project inflow in response to work pressure. It is a difficult area for a few major reasons. In many cases the project organization may have spent a considerable effort

in convincing clients of the "great things" it can do for them. When the organization becomes overloaded, it becomes exceedingly difficult to turn down a new "convert". Furthermore, it is tempting for the project staff to expand a project. Opportunities present themselves in the course of the project development to do something extra about which the staff feels enthused. It takes time, however, and tends to overload the organization. Most project managers recognize these situations. It appears from the simulation runs that it is essential that management be firm in regulating the inflow. The difficulties, of course, are greater for the competent organization, because it is more likely to be pressured by too many possible projects. The simulation runs did not deal with the effect on the potential inflow of the competence level as it is perceived by the clients, but it seems obvious that the greater the competence, the greater the potential number of projects, and the greater the pressure to overload the system. Rather than giving in to such pressure, it should be considered an excellent opportunity to select the most profitable project.

5.1 SUGGESTIONS FOR FURTHER STUDY

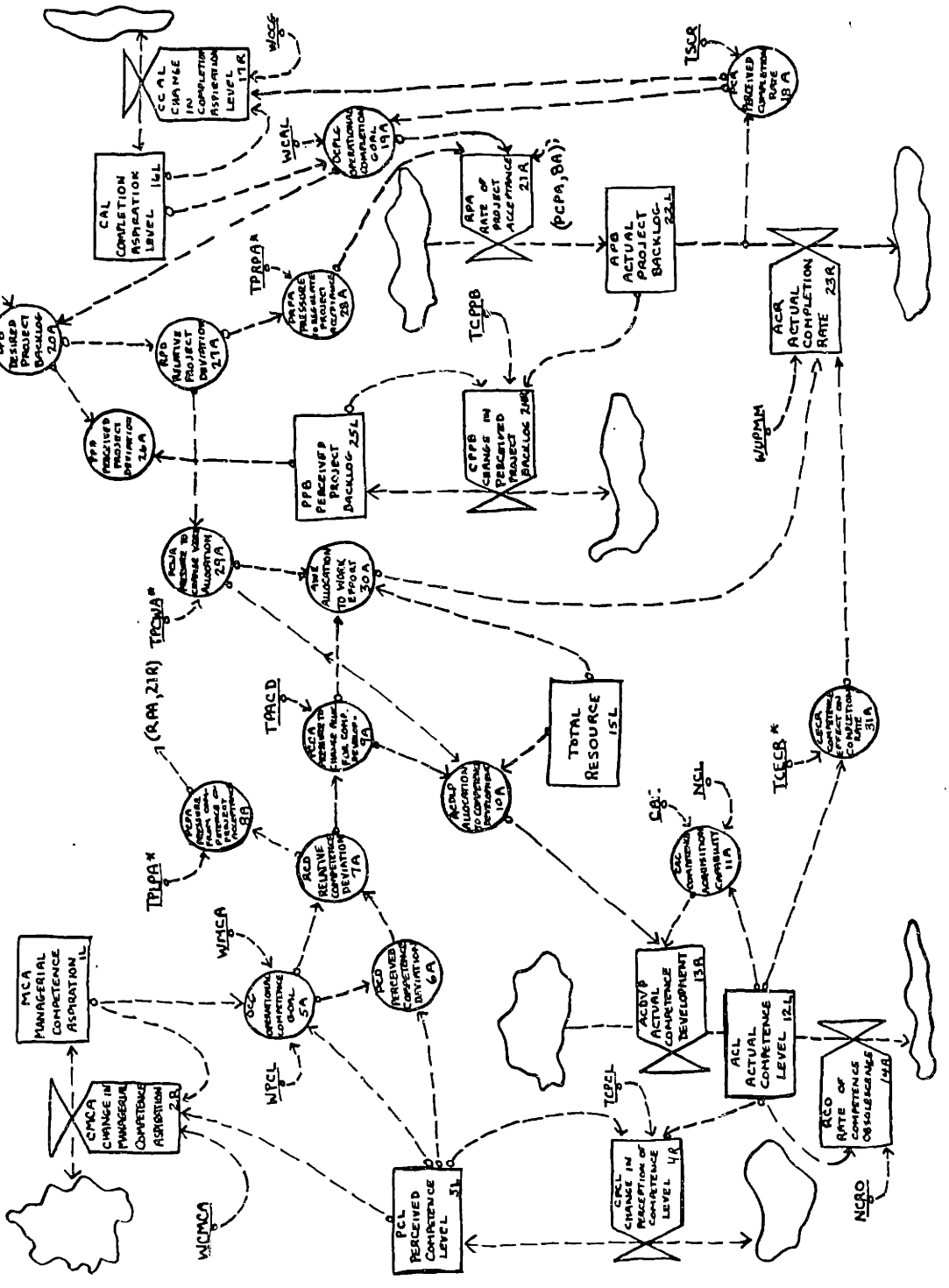
The model was designed to provide a basis for management decision-making at the strategic level. The focus was on the effect of alternative managerial strategies relating to the internal dynamics of the project organization. The interface with the environment was not included.

The project organization interfaces with the environment in several ways. The service it provides is consumed by clients, and there are obvious relations between the performance of the project organization and the inclination of potential clients to seek its services. Furthermore, the project organization interfaces with its environment through the acquisition of the human and other resources used in the project work.

The strategy that management would like to adopt would depend very much on the specific characteristics of both the market for its services and the market for its resources. The model could, therefore, be fruitfully expanded to encompass the feedback loop going through the quality of the output to the clients' perception of the competence to the clients' inclincation to seek the services of the organization. It could also be expanded to encompass personnel turnover, voluntary or otherwise, and training of new employees in response to increases or decreases in the workload.

Having dealt with the problem at the strategic level, a further logical step would be for the project management to attempt to make the results operational by changing the departmental policies in terms of control systems, reward systems, hiring practices and educational practices, to conform to the conclusions drawn from the simulation of its specific environment.

Appendix A - Detailed Simulation Model



APPENDIX B

DYNAMO SIMULATION MODEL - 25% UNDERESTIMATION OF PROJECT WORKLOAD AT MONTH 2

```
//JOBLIB   DD  DSNAME=SYS5.DYNAMO.LOAD,DISP=OLD
//RUN    EXEC  DYNAMO
//G.SYSIN  DD  *
NOTE  MODEL OF PROJECT MANAGEMENT
NOTE
NOTE  COMPETENCE GOAL MAINTENANCE
NOTE
1L    MCA.K=MCA.J+(DT)(CMCA.JK+0)
6N    MCA=100                          COMPETENCE UNITS
21R   CMCA.KL=(1/WCMCA)(PCL.K-MCA.K)
C     WCMCA=24              MONTHS
1L    PCL.K=PCL.J+(DT)(CPCL.JK+0)
6N    PCL=100                          COMPETENCE UNITS
21R   CPCL.KL=(1/TCPCL)(ACL.K-PCL.K)
C     TCPCL=12          MONTHS
15A   OCG.K=(WMCA)(MCA.K)+(WPCL)(PCL.K)
C     WMCA=.5
C     WPCL=.5
20A   RCD.K=PCD.K/OCG.K
7A    PCD.K=PCL.K-OCG.K
1L    ACL.K=ACL.J+(DT)(ACDVP.JK-RCD.JK)
6N    ACL=100                COMPETENCE UNITS
12R   ACDVP.KL=(CAC.K)(ACDLP.K)
44A   CAC.K=(CAF)(ACL.K)/NCL
C     CAF=.4
C     NCL=100            COMPETENCE UNITS
20R   RCO.KL=ACL.K/NRCC
C     NRCO=50       MONTHS
NOTE
NOTE  COMPLETION GOAL MAINTENANCE
NOTE
1L    CAL.K=CAL.J+(DT)(CCAL.JK)
6N    CAL=100                   WORK UNITS PER MONTH
21R   CCAL.KL=(1/WCCG)(PCR.K-CAL.K)
C     WCCG=36              MONTHS
3L    PCR.K=PCR.J+(DT)(1/TSCR)(ACR.JK-PCR.J)
6N    PCR=100                   COMPLETION RATE IN WORK UNITS
C     TSCR=6       MONTHS
15A   OCPLG.K=(WPCR)(PCR.K)+(WCAL)(CAL.K)
C     WCAL=.5
C     WPCR=.5
59A   PRPA.K=TABLE(TPRPA,RPD.K,-.5,.5,.1)
C     TPRPA*=0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2
20A   RPD.K=PPD.K/DPB.K
7A    PPD.K=DPB.K-PPB.K
12A   DPB.K=(OCPLG.K)(DMPB)
C     DMPB=12               DESIRED MONTHS OF PROJECT BACKLOG
52L   APB.K=APB.J+(DT)(RPA.JK-ACR.JK+PU.J+0)
41A   PU.K=PULSE(300,1,150)
6N    APB=1200           WORK UNITS
13R   RPA.KL=(OCPLG.K)(PRPA.K)(PCPA.K)
59A   PCPA.K=TABLE(TPCPA,RCD.K,-.5,.5,.1)
C     TPCPA*=0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2
13R   ACR.KL=(WUPMM)(AWE.K)(CECR.K)
C     WUPMM=5                WORK UNITS PER MONTH
59A   CECR.K=TABLE(TCECR,ACL.K,40,140,10)
C     TCECR*=0/.23/.42/.6/.75/.88/1/1.1/1.18/1.22/1.25
1L    PPB.K=PPB.J+(DT)(CPPB.JK+0)
6N    PPB=1200           WORK UNITS
21R   CPPB.KL=(1/TCPPB)(APB.K-PPB.K)
```

```
C       TCPPB=6             MONTHS
NOTE
NOTE ALLOCATION OF STAFF BETWEEN COMPETENCE MAINTENANCE AND
NOTE   PROJECT WORK EFFORT
59A     PCCA.K=TABLE(TPACD,RCD.K,-.5,.5,.1)
C       TPACD*=.9/.5/.35/.25/.225/.2/.185/.15/.08/0/0
59A     PCWA.K=TABLE(TPCWA,RPD.K,-.5,.5,.1)
C       TPCWA*=3.2/2/1.4/1/.9/.8/.74/.6/.32/0/0
C       TR=25           MEN
50A     ACDLP.K=(PCCA.K)(TR)/(PCCA.K+PCWA.K)
50A     AWE.K=(PCWA.K)(TR)/(PCCA.K+PCWA.K)
NOTE
NOTE   RELATIVE MEASURE OF SUCCESS
NOTE
1L      AACR.K=AACR.J+(DT)(ACR.JK+0)
6N      AACR=0
NOTE
NOTE   OUTPUT
NOTE
PRINT 1)MCA/2)MCG/3)PCL/4)ACL/5)ACR/6)APB/7)PPB/8)CAL/9)CCPLG/10)AACR/11
X1      )PPD
PLOT    MCA=A,PCL=C,ACL=D,CAL=E,CCPLG=F/ACR=I,RPA=K/RPD=P,RCD=R/AWE=W
SPEC    DT=1/LENGTH=120/PRTPER=3/PLTPER=3
RUN     NORMU
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=3
C       WPCR=.7
C       WCAL=.3
C       TSCR=4
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTU1
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TCPPB=3
C       WPCR=.7
C       WCAL=.3
C       TSCR=4
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTU2
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
```

```
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTU3
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTU4
C       TPCWA*=40/20/4/1.6/1.12/.8/.48/0/0/0/0
C       TPACD*=.4/.33/.28/.24/.21/.2/.19/.16/.12/.07/0
C       TCPPB=3
C       WPCR=.3
C       WCAL=.7
C       TSCR=4
C       WCCG=72
C       TCPCL=6
C       WPCL=.5
C       WMCA=.5
C       WCMCA=48
RUN     STRTU5
C       TPCWA*=40/20/4/1.6/1.12/.8/.48/0/0/0/0
C       TPACD*=.4/.33/.28/.24/.21/.2/.19/.16/.12/.07/0
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=3
C       WPCR=.3
C       WCAL=.7
C       TSCR=4
C       WCCG=72
C       TCPCL=6
C       WPCL=.5
C       WMCA=.5
C       WCMCA=48
RUN     STRTU6
```

DYNAMO SIMULATION MODEL - 10% CONTINUOUS
BIAS IN PROJECT ESTIMATION

```
//JOBLIB   DD  DSNAME=SYS5.DYNAMO.LCAD,DISP=OLD
//RUN    EXEC  DYNAMO
//G.SYSIN  DD  *
NOTE  MODEL OF PROJECT MANAGEMENT
NOTE
NOTE  COMPETENCE GOAL MAINTENANCE
NOTE
1L    MCA.K=MCA.J+(DT)(CMCA.JK+0)
6N    MCA=100                          COMPETENCE UNITS
21R   CMCA.KL=(1/WCMCA)(PCL.K-MCA.K)
C     WCMCA=24              MONTHS
1L    PCL.K=PCL.J+(DT)(CPCL.JK+0)
6N    PCL=100                          COMPETENCE UNITS
21R   CPCL.KL=(1/TCPCL)(ACL.K-PCL.K)
C     TCPCL=12          MONTHS
1L    OCG.K=(WMCA)(MCA.K)+(WPCL)(PCL.K)
C     WMCA=.5
C     WPCL=.5
7A    PCD.K=PCL.K-OCG.K
20A   RCD.K=PCD.K/OCG.K
1L    ACL.K=ACL.J+(DT)(ACDVP.JK-RCO.JK)
6N    ACL=100                 COMPETENCE UNITS
12R   ACDVP.KL=(CAC.K)(ACDLP.K)
44A   CAC.K=(CAF)(ACL.K)/NCL
C     CAF=.4
C     NCL=100           COMPETENCE UNITS
20R   RCO.KL=ACL.K/NRCO
C     NRCO=50       MONTHS
NOTE
NOTE  COMPLETION GOAL MAINTENANCE
NOTE
1L    CAL.K=CAL.J+(DT)(CCAL.JK)
6N    CAL=100                   WORK UNITS PER MONTH
21R   CCAL.KL=(1/WCCG)(PCR.K-CAL.K)
C     WCCG=36               MONTHS
3L    PCR.K=PCR.J+(DT)(1/TSCR)(ACR.JK-PCR.J)
6N    PCR=100                    COMPLETION RATE IN WORK UNITS
C     TSCR=6       MONTHS
15A   OCPLG.K=(WPCR)(PCR.K)+(WCAL)(CAL.K)
C     WCAL=.5
C     WPCR=.5
12A   DPB.K=(OCPLG.K)(DMPB)
C     DMPB=12               DESIRED MONTHS OF PROJECT BACKLOG
7A    PPD.K=DPB.K-PPB.K
20A   RPD.K=PPD.K/DPB.K
12A   CAP.K=(PRPA.K)(PCPA.K)
13R   RPA.KL=(OCPLG.K)(CAP.K)(DOPA)
C     DOPA=1.1
59A   PRPA.K=TABLE(TPRPA,RPD.K,-.5,.5,.1)
C     TPRPA*=0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2
59A   PCPA.K=TABLE(TPCPA,RCD.K,-.5,.5,.1)
C     TPCPA*=0/.4/.6/.75/.9/1/1.1/1.25/1.4/1.6/2
1L    APB.K=APB.J+(DT)(RPA.JK-ACR.JK)
6N    APB=1200          WORK UNITS
13R   ACR.KL=(WUPMM)(AWE.K)(CECR.K)
C     WUPMM=5                WORK UNITS PER MONTH
59A   CECR.K=TABLE(TCECR,ACL.K,40,140,10)
C     TCECR*=0/.23/.42/.6/.75/.88/1/1.1/1.18/1.22/1.25
1L    PPB.K=PPB.J+(DT)(CPPB.JK+0)
6N    PPB=1200            WORK UNITS
```

```
21R   CPPB.KL=(1/TCPPB)(APB.K-PPB.K)
C     TCPPB=6            MONTHS
NOTE
NOTE ALLOCATION OF STAFF BETWEEN COMPETENCE MAINTENANCE AND
NOTE  PROJECT WORK EFFORT
59A   PCCA.K=TABLE(TPACD,RCD.K,-.5,.5,.1)
C     TPACD*=.8/.5/.35/.25/.225/.2/.185/.15/.08/0/0
59A   PCWA.K=TABLE(TPCWA,RPD.K,-.5,.5,.1)
C     TPCWA*=3.2/2/1.4/1/.9/.8/.74/.6/.32/0/0
C     TR=25          MEN
59A   ACDLP.K=(PCCA.K)(TR)/(PCCA.K+PCWA.K)
59A   AWE.K=(PCWA.K)(TR)/(PCCA.K+PCWA.K)
NOTE
NOTE  RELATIVE MEASURE OF SUCCESS
NOTE
1L    AACR.K=AACR.J+(DT)(ACR.JK+0)
6N    AACR=0
NOTE
NOTE  OUTPUT
NOTE
PRINT 1)MCA/2)DCG/3)PCL/4)ACL/5)ACR/6)APB/7)PPB/8)CAL/9)DCPLG/10)AACR/11
X1    )PPD
PLOT  MCA=A,PCL=C,ACL=D,CAL=E,DCPLG=F,ACR=I,RPA=K/RPD=P,RCD=R/AWE=W
SPEC  DT=1/LENGTH=120/PRTPER=3/PLTPER=3
RUN   NORMB
C     TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C     TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C     TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C     TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C     TCPPB=3
C     WPCR=.7
C     WCAL=.3
C     TSCR=4
C     WCCG=18
C     TCPCL=6
C     WPCL=.2
C     WMCA=.8
C     WCMCA=72
RUN   STRTB1
C     TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C     TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C     TCPPB=3
C     WPCR=.7
C     WCAL=.3
C     TSCR=4
C     WCCG=18
C     TCPCL=6
C     WPCL=.2
C     WMCA=.8
C     WCMCA=72
RUN   STRTB2
C     TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C     TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C     TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C     TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C     TCPPB=12
C     WPCR=.7
C     WCAL=.3
C     TSCR=8
C     WCCG=18
```

```
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTB3
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTB4
C       TPCWA*=40/20/4/1.6/1.12/.8/.48/0/0/0/0
C       TPACD*=.4/.33/.28/.24/.21/.2/.19/.16/.12/.07/0
C       TCPPB=3
C       WPCR=.3
C       WCAL=.7
C       TSCR=4
C       WCCG=72
C       TCPCL=6
C       WPCL=.5
C       WMCA=.5
C       WCMCA=48
RUN     STRTB5
C       TPCWA*=40/20/4/1.6/1.12/.8/.48/0/0/0/0
C       TPACD*=.4/.33/.28/.24/.21/.2/.19/.16/.12/.07/0
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=3
C       WPCR=.3
C       WCAL=.7
C       TSCR=4
C       WCCG=72
C       TCPCL=6
C       WPCL=.5
C       WMCA=.5
C       WCMCA=48
RUN     STRTB6
C       TPCWA*=.8/.8/.8/.8/.8/.8/.8/.8/.8/.8/.8
C       TPACD*=.2/.2/.2/.2/.2/.2/.2/.2/.2/.2/.2
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=72
RUN     STRTB7
C       TPACD*=10/5/1/.4/.28/.2/.12/0/0/0/0
C       TPCWA*=1.6/1.32/1.12/.96/.84/.8/.76/.64/.48/.28/0
C       TPRPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
```

```
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=1000
RUN     STRT88
```

```
C       TPCPA*=0/0/0/.5/.8/1/1.2/1.5/2/2.8/4
C       TCPPB=12
C       WPCR=.7
C       WCAL=.3
C       TSCR=8
C       WCCG=18
C       TCPCL=6
C       WPCL=.2
C       WMCA=.8
C       WCMCA=1000
RUN     STRTB8
```

Appendix C - OVERVIEW OF STRATEGIES TESTED

		Neutral	Competence Centred 3.1	3.2	3.3	3.4	Completion Centred 3.5	3.6	No Reallocation 4.1	Constant Competence Aspiration 4.2
Competence Goal Structure										
WCMCA	(months)	24	72	72	72	72	48	48	72	1000
WMCA	(weight)	.5	.8	.8	.8	.8	.5	.5	.8	.8
WPCL	(weight)	.5	.2	.2	.2	.2	.5	.5	.2	.2
TCPCL	(months)	12	6	6	6	6	6	6	6	6
Completion Goal Structure										
WCCG	(months)	36	18	18	18	18	72	72	18	18
TSCR	(months)	6	4	4	8	8	4	4	8	8
WACPG	(weight)	.5	.3	.3	.3	.3	.7	.7	.3	.3
WPCR	(weight)	.5	.7	.7	.7	.7	.3	.3	.7	.7
TCPPB	(months)	6	3	3	12	12	3	3	12	12
TABLES										
TPCPA*	(table No.)	2.1	3.2A	3.2B	3.2A	3.2B	3.2B	3.2A	3.2A	3.2A
TPACD*	(table No.)	2.3	3.1A	3.1A	3.1A	3.1A	3.1B	3.1B	4.1	3.1A
TPRPA*	(table No.)	2.1	3.2A	3.2B	3.2A	3.2B	3.2B	3.2A	3.2A	3.2A
TPCWA*	(table No.)	2.3	3.1B	3.1B	3.1B	3.1B	3.1A	3.1A	4.1	3.1A
Results (total work units)										
Underestimate once		11.355	11942	11855	11950	11893	8689	11103		
10% continuous bias		11.048	11902	11815	11902	11806	7900	10385	12000	11925

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