CAN PROJECT DYNAMICS BE MODELLED?

BY

SVEIN ARNE JESSEN

HENLEY MAY 2nd 1988

Svein Arne Jessen
Henley The Management College
Greenlands, Henley-on-Thames
OXON RG9 3AU
UK

ABSTRACT

The paper discusses the author's version of some of the pros et cons in modern project modelling. His main view is that projects have many features that make them well fitted for using the Systems Approach in the analysis and improvement of their performance, but many of the traditional "rules" for "correct" project execution and monitoring should be questioned. He particulary advocates revision of (1) the traditional firm definition of project boundaries as time, cost and quality which, because of the uniqueness and unpredictability of project work, almost always have to be changed or adjusted, but where advice on which one to "adjust" when under pressure seldom exists (2) the necessity of basing the project performance on a strict "sequencing" of the project work when real life project work often experiences substantial "overlapping" between project phases, and (3) using common rigid organizational structures in a project environment where the real requirement is structures that favour the mastering of fast changes and organizational flexibility.

The author then elaborates on how the three arguments above could be part of a more "complete" project model, including a much stronger emphasis on the human factor as a major component in dealing with the suggested more complex nature of project work.

This leads to the authors own version of a more comprehensive Project Dynamic Model. The model is described in the paper by its main features and some of its initial findings, but a fully computer-implemented model using the STELLA compiler will be demonstrated at the conference based on the research being undertaken by the author.

The author:

Svein Arne Jessen is Assistant Professor in Project Management at the Norwegian School of Management in Norway. He is currently at Henley The Management College researching into Project Modeling, and has earlier spent one year at the University of Southern California, Institute of Safety and Systems Management, Laboratory of System Dynamics. Jessen has extensive experience of project work in countries in Scandinavia, Asia and Africa, and has had positions both as Project Manager, Managing Director and Management Consultant throughout the last 30 years.

5.2. FEATURES OF A MORE COMPREHENSIVE PROJECT DYNAMIC MODEL

5.2.1. One of the main characteristics of projects is their uniqueness. Breaking new ground is often unpredictable, very often troublesome, and almost always risky. Due to their nature project situations are, of course, always situational and any project model will subsequently suffer from its inability to fully cope with the real future. It can only look backwards and then impose structures on what has been enacted in its name. If a project model in addition is to be of value as a decision support tool, it must appeal to the decision maker through its;

a) simplicity and understandability,
b) correctness in its theory of project operations, and
c) detail and realism

5.2.2. Obviously this is not an easy task. In the stepwise explanation of my "Total Project Dynamic Model" which I have tried to develop (Fig.5.2.5.) I have used as my main input two sources:

Source I: A database of 120 different projects collected throughout the last 3 years through questionnaires to project participants followed by personal interviews with a majority of them. Besides basic technical information on project size, time frame, budgets and costs, etc., questions about the participants motivation in different phases, their feeling of skill improvement throughout the project course and their feeling of success or failure were recorded. The database also contains 29 projects where I have participated myself, in more than half of them as Project Manager.

Source II: My own (presumably) sound judgement based on more than 25 years of experience as project participant either as team member ,Project Manager or member of Steering Committee or Advisory Board.

5.2.3. To comprehend this database to be useful as a model input, I am fully aware that the above mentioned "simplicity" could easily end up as over-simplification; the "understandability" declared confusion; the "correctness" in its description of project operations could be attacked as being limited to cases brought forward by the author; and the "realism" heavily overshaded by" details". My only comfort and defence is that when calibrating the model, information from 120 real projects served as input, and when evaluating the output I found that it renarrated surprisingly and appealingly well all the misfortunes, and a few successes, I have experienced myself as project participant.

5.2.3. I therefore believe that although many project situations cannot be programmed because of the unique nature of the project work, the combination of project experience and observations in a project model laboratory can increase the awareness of problem areas and bottlenecks as well as encourage the right use of the many techniques that are highly appliable during the course of a project life with often highly rewarding and tangible results.

5.2.4. Some of the key elements in the model are naturally taken from other studies in this field, for instance the important distinction between "real progress" and "perceived progress" (Roberts: 1974) , the clarifying term "undiscovered rework" in project management modeling (Richardson & Pugh: 1983), the "enactment" and "selection" notion (Weigh: 1979), the dynamic modeling of "stress" as both an encouraging and retarding factor (Homer: 1985), the clarifying distinction between "productivity", "efficiency" and "effectiveness" in models (Joynt: 1986), the "ripple effects" in system dynamics modeling leading to unintentional changes (Hout & Cooper: 1981), the reciprocal effect between "project estimation" and "project behaviour" (Abdel-Hamid: 1985), the "winner " and "looser" syndrome in team- and group work (Schein: 1973), the "will" and "skill" of productivity in project work (Obradovitch: 1981), the effect of "learning" as a project parameter (Cleland: 1984) and the long discussed possible relationship between "motivation" and "productivity" in general (McGregor et al).

5.2.5. The resulting "Total Project Dynamic Model" is based on the simple System Dynamic principle of goal-seeking processes. The goal-seeking mechanism in a project then being that goal directed decisions are taken as a consequence of discrepancy between a desired project goal and an observed project progress (Fig.5.2.5.).

5.2.6.Although the simple causal-loop diagram below is only the first step in adequately modeling the complex processes of a project system, the diagram at this stage already poses some critical questions of earlier project model thinking and ~~enhance~~ offers a more comprehensive view of project dynamics (letters ref. to Fig. 5.2.5.).

5.2.7. Following the letters identifying connections and processes around the figure, the following comments can be made:

a) Many of the simulation models built so far relate to R&D-projects (Roberts: 1974 ; Robertson & Pugh: 1983), and assume that the ultimate goal expressed as a predefined number of (optimally completed) tasks triggers the continuous action throughout the project life. This is not necessarily always the case. More often the "goal" will be a mixture of finishing according to some predefined end-product standard, defined by the client at project start, and to run the project according to a contractualized project plan with milestones, check-points and even day-to-day controling mechanisms. For some projects, success is in fact directly measured as to which degree the project seems to follow its plan, for others only to which degree the client is satisfied with the end product regardless of how minutely a plan is followed.

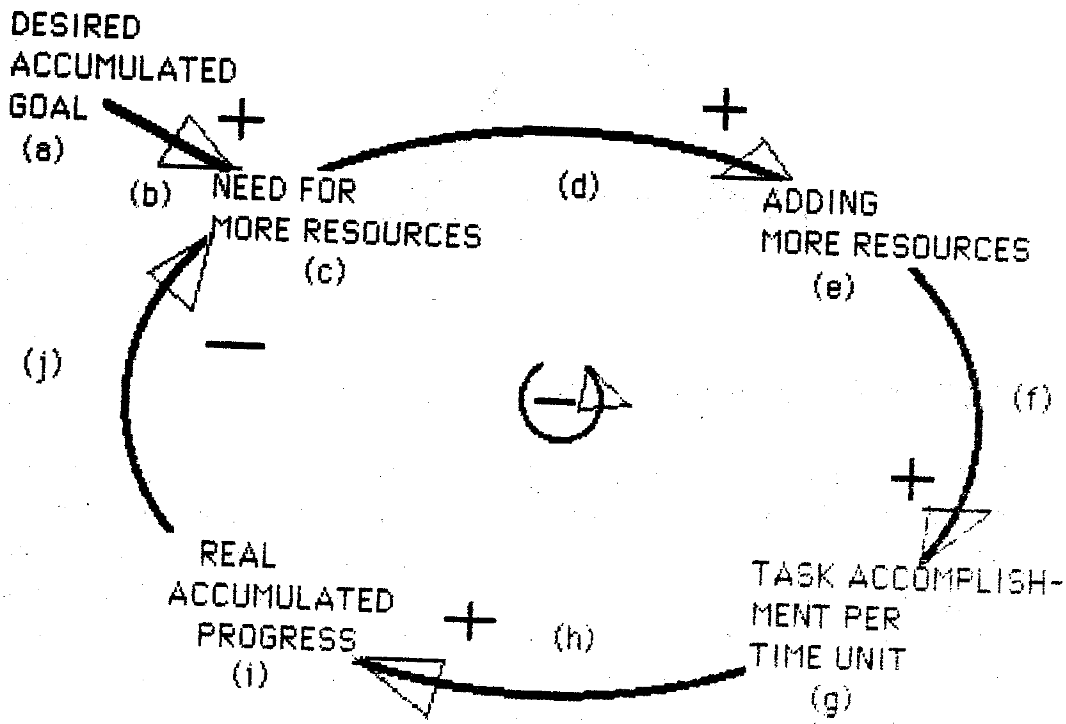


Fig.5.2.5. Simplified Causal-loop Diagram for the Total Project Dynamic Model

The "goal" should somehow reflect this, for instance by being described both as a desired number of work-"units" to be done, and a resource "profile" serving as the running guideline for the physical project performance. By introducing some kind of "weight-factors" explaining what is the most important in each particular project or "type" of project, not only will the way projects technically develop differ, but also the very sensitive motivational aspect will be brought to attention as well as its influence on the project executer's performance.

b) A presupposition in goal-seeking System Dynamic models seems to be that the goal holds its initial definition throughout the whole project process. This is both a simplification and a slight misconception of the nature of project goals (Gottschalk, 1984 ; Gottschalk & Wenstøp: 1983). In modern project management the proper goal description has at least three basic components : the quality of the end product, the time-frame within which the quality is supposed to emerge, and the financial constraint to which the project has to adhere, often as a function of human resource expenditures (Fig.5.2.6.).

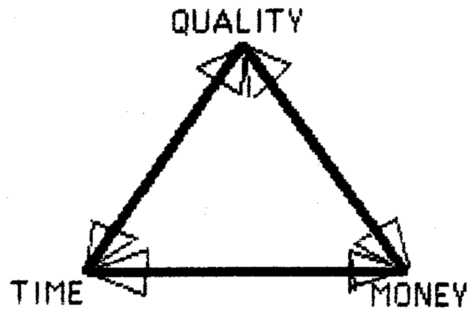


Fig.5.2.6. The Three Basic Components Of Project Goals

The three components are strongly interconnected. If there is a risk of quality slippage, and quality is imperative for the end product, either time or money or both have to slip. Which one is an important management decision. If to keep the scheduled time is the prerequisite, quality or money would have to slip. (or the project completely stop!). If no more money can be used than originally budgeted, quality may have to decease, etc.
These are the really important policy questions facing modern project management. A realistic project model should reflect this, demonstrating through feed-back systems how the three goal components could and should be adjusted as the project proceeds.

c) The discrepancy between the desired state and the real state of the project progress determines which possible actions to take. If the discrepancy is "negative", or less is achieved than planned and expected, the choice is whether to increase the human resource input, which will directly or indirectly cost money (Somers: 1982), or the time, which will prolong the project, or to reduce the quality requirements, which could upset the client or the customer (Hout & Cooper: 1981), and of course change the technological input, which could affectboth money, time and people.
According to which of the goal constraints that would be the most important to maintain at its original definition, a classification of projects based on their goal structure is tried below. By using the former mentioned project data-base as the source there could to be reason to identify at least three main classes of projects:

	The Time constraint	The Financial constraint	The Quality constraint
<u>Class I:</u> Construction-type projects	Can be allowed to "slip" to some degree	Generally very impor- tant to keep	Can be allowed to "slip" to some degree
<u>Class II:</u> R & D -type projects	Can often be allowed to"slip"	Can be allowed to "slip" to some degree	Generally very impor- tant to keep
<u>Class III:</u> Decision-Support-type projects	Generally very impor- tant to keep	Can be allowed to "slip" to some degree	Can be allowed to "slip" to some degree

<u>Construction-type</u> projects are here defined as the building of physical complexes as houses, industrial plants, roads, etc., and are often recognized by their size and their extensive use of technical planning aids as Network techniques, PERT diagrams, etc. Also their control and monitoring systems are often technically advanced/computerized and the projects often involves many parties/subcontracters that are mutually dependent on each other.

<u>R & D-type</u> projects, or Research- and Development projects, are here defined as the typical breaking-new-ground projects. Their size can range from very large to very small, their development pattern can be very "disorderly", though the final aim can be very concrete. Typical examples are laboratory research projects, the development of new machinery, the development of new computer software, etc.

<u>Decision-Support-type</u> projects are here defined as projects that ends up with a report, a document, a recommendation for instance for a committee or a Ministry, or even a full feasibility study for a later construction- or R&D-project. These projects are often not ends themselves, but gives decision support for eventual further action. Their size are generally small, and their main guideline a given deadline for their delivery instituted by the project "client". The quality will directly depend on how much the project team is able to produce within the time (and often cost) limit given.

A clear distinction between these "classes" can of course in many cases be difficult. But to treat projects differently depending on their final aim, also at the model stage, could probably be of help in improving our understanding of project processes. Not only due to "physical" differences, but also because project team behaviour seems to change according to the way the project definition is done (Abdel-Hamid: 1984), implying that varying attitudes to discrepancies may create completely different situations in respect of for instance motivation and learning in projects.

d) The arrow between the observed need for more resources and the actual allocation of resources, is one of the crucial decision areas in project management (Katz & Allen: 1985), probably in management in general. At least two questions are basic:

i) Who shall take such a decision?

ii) How will the delay between the time the information is given and the allocation takes place affect the project performance?

As for i) the decision maker(s) could be the project team itself, or it could be the project manager, or the project Board, if constituted, or the project "owner", top management, a client or a customer The less this decision body is directly involved with the project, however, the more it is probable that circumstances outside the project will influence this decision both in respect of "delivery" time and the amount of additional resources granted. Typical "outside" circumstances affecting this decision are changing business environment, changing company policies, changing priorities among projects and even changing personal preferences among high officials. Assuming scarce resources being the general rule for most companies, the subsequent allocation could differ in, from the project point of view, random and unfavourable ways from the computed project need, forcing dramatic changes in need assessment and team motivation in the next round.

Not only will this differ from one type of project to another, but it could also differ from one project-phase to another. Over the project life-cycle it is not uncommon that decisions related to the earlier and the late phases, for instance initiation and termination, are taken by agencies completely outside the project while execution and monitoring decisions are the responsibility of the people directly involved with the project work. This "dualistic" decision system should somehow be reflected in a project model.

As for ii), the same "dualism" tends to influence the speed of the decision-taking as well. Outside agencies may need extra time to gather sufficient information on competing and threatening events to the project in order to get a more comprehensive view before they make up their mind and actually decide. This could delay and even ruin the often minutely planned monitoring system for some types of projects, for instance construction-type projects. A realistic project model should reflect such implications, also how this may affect the motivation of the project executors

e) When the project control system reveals that there is a discrepancy between the planned and arranged resource use and the real resource need in order to reach the project goal, several options are available for bridging this gap. If the project goal is constrained by time, money and quality , the keeping of one of these constraints means, as discussed earlier, to slip one or both of the other:

i) Increasing the "monetary" frame, or the budget, may imply:

1) Purchase of new technology to substitute the human resource component in order to keep time and quality (Cooper: 1980)
2) Purchase of additional human resources in order to keep time and quality
3) Purchase of additional human capacity, for instance by "buying" overtime, to keep quality and calendar-time

ii) Increasing the "time" frame may imply:

1) Replanning and reallocation of the other resources, which could entail heavy indirect cost components as additional administration, supervision and communication (Abdel-Hamid & Madnick: 1985)
2) "Off-spring" activities which are beneficial to the project, and the company, in the long run, but which have no measurable benefits for the on-going project (Roberts: 1974)

In general, keeping a desired quality when original constraints are discovered to have been unsatisfactorily dimensioned, can only be done by accepting undesired slippages of time and money. Either by making high professional executers do more work in less time, or by making "standard" executers do the same work in more time (Richardson & Pugh: 1983). To make the picture even more complicated, the need for more resources could as well be both "positive" and "negative", depending on how accurately new resourcesare dimensioned, implying frequent alterations between deduction and increase of resources as a result. Even if this creates less problems in some cultures, it surely is much easier to hire people than fire people in others -

f) It is reasonable to assume that the adding of more human resources to a project results in more tasks accomplished per time unit. The important question is however, how much more ? Two factors seems to demand special attention here

i) The total number of tasks that will be done with more people brought in to the project.
ii) The total number of tasks relevant to the project that will be done with more people brought in

While both accomplishments depend on the workforce's capacity and motivation (Roberts: 1974, Richardson & Pugh: 1983), the first one might be much larger than the latter because of "distraction" (Roberts: 1974) or due to so-called "ripple effects" (Huot & Cooper: 1981). The difference will depend on many factors, as when additional staff are brought in, how their level of expertise is compared to existing project staff, to which degree they are full time or fraction time allocated to the project, etc.

We know there is a positive correlation between project performance and motivation. But we also know that high motivation does not necessarily mean high productivity according to the project objectives , and also that motivation can be remarkably high in projects fighting their way through numerous obstacles and even not necessarily ending up with obvious success. We also know that management seems to play a major role in positive and negative motivation, and that our modern societies encourage involvement and understanding for its members as an important input for good work performance (Schein:1985; Erez: 1985). What we do not know is how important motivation is? Can high motivation really substitute the slippage of money, time and quality, and if so, to which degree and can it be measured?

The capacity to do the work, i.e. the professional capability of the project team, is of course another important factor. This has also been included in many models, and often taken into account as a maximum number of top-skilled people available at each point in time by any organization. If this upper limit is important to the project in question, the model must assume a decreasing (in-house) capasity when additional highly skilled capasity is transferred to the project from the base organization.

Even though the above mentioned features are incorporated in many of today's models of project management, some refinement might be necessary, particulary when moving from a general model to models made for particular classes of projects. Also it could be advisable to analyse the effect of de-motivation caused by certain decisions and negative attitudes from the project environment when restaffing and altering of team composition takes place

g) The "task accomplishment per time unit" brings in the importance of efficiency, effectivity, and organizational culture (OC) Although these terms are connected, they will have quite different normative definitions in a project context "Efficiency" could probably be described as the "effective project output" divided by the "amount of produce" consumed by the project, while the "effectivity" could be defined as the project "goal

fulfillment" divided by the "use of resources".
These amounts can be measured as the project proceeds which is also done in many project models. The outcome is then used as a basic parameter for new decisions (Forrester: 1961, Roberts.1974 Somers: 1982, Richardson & Pugh: 1983, Abdel-Hamid: 1984). As for Organizational Culture, this area has received much recent attention from modern organizational scientists and organizational consultants, demonstrating the economic value of certain OC's (Peter & Waterman: 1982). Any inclusion of these aspects at a model level has though not yet been done.
Some researchers have, however, questioned the human limits in these parameters, warning that progress is a product of "will" and "skill" which both have limitations (Obradowitch: 1976-1981) Other modellers have pointed to the fact that continuing pressure over time can cause "stress" and subsequent "burnout" (Homer. 1985), and others again that if persistent opposition towards a group-effort dominates the group environment, a "loser" and "winner" mentality can develop disturbing and diverting the original goal-oriented effort (Schein: 1985).
Probably some of these observations need to be included in more comprehensive project modeling.

h) One of the major contributions to project modeling, was probably the introduction of "undiscovered rework" (Richardson & Pugh: 1983). The obvious observation that all work or tasks done in a project do not necessarily mean that all tasks have been done correctly, made it quite easy to explain why projects, particulary R&D-projects. almost as a law of nature experienced overruns. This has been further explained as a result of the very nature of projects (Graham. 1985):

- Since a project is unique, the end product is often not fully specified in advance
- The total process for producing the not-fully-specified product is itself often not fully specified

Project management therefore, in each project, should initially decide which kind of "overrun" that will be the most acceptable. To fully prevent overruns is of course theoretically possible, for instance by hiring such well qualified people that they never make mistakes either in the planning phase or in the execution phase. This is not possible. Another option is to include training as an in-built requirement from the very beginning of the project and thus accept rework as part of the process (Cleland: 1984). The problem then of course will be to predict the training effect. The training component has the negative effect that it can inhibit the effectiveness of experienced workers (Richardson & Pugh 1983), or the benefit comes only in future projects, which is not easy to argue for when the main aim is to make the present project beneficial

In a quite extensive and very interesting "demonstration" project model as part of the STELLA compiler, variables as "managerial direction" and "managers aggressiveness" have been introduced, but not as part of any feed-back mechanism. It nevertheless points to the fact that human intervention most certainly have to be considered in future project modeling.
Conclusively therefore, a better policy seems to be to accept rework as a natural "weakness" in project execution and then construct reasonable physical and psychical counter-mechanisms as part of the project execution process.

i) Because of the "rework"-factor above, the real progress tend not to be the basis for the actions that take place in the project. It is the perceived status that triggers the decision-makers to take action to change the rates of the system and thus its future state. This moves the conceptualization from the strict, physical processes to perceptions (Roberts: 1974). Which again broadens the project scope significantly. Projects can no longer be only a technology domain, but has to include quite a lot of cross-diciplinary understanding of how organizations and individuals perform, perceive and behave.
It is in this respect encouraging to note that the few System Dynamic models developed so far have all taken some of these relationships into consideration. How to fully take account of the gap between the illusory comprehension of the project progress and the real project progress has though yet to be done, particulary in respect of the motivational influence such relationships have on the project participants.

j) The last link in the causal-loop diagram, is the connection between the observable progress and the discrepancy function (c), assessing the future resource needs. Traditionally this has in a modeling environment been looked upon as a continuous "mathematical" function where remaining effort towards the final goal fulfillment was the prime measurement (Roberts: 1974, Somers: 1982, Richardson & Pugh: 1983).
The introduction of phased project management and delegated responsibility to sub-units (Smid: 1986), has brought new thoughts both on technical performance and motivation into the picture. When projects no longer can be regarded as continuous events, at least not throughout their full lifecycle, the passing from one phase to another has to be adequately expressed in the model. One way to do it could be to treat the project as performances by different working groups, letting each group in the model behave like a continuous sub-project responsible for a certain time-limited phase of the total project. Another is to overlap the project phases in such a way that new phases, for instance the project execution can start before the project planning is finalized etc.

Such policy changes will naturally mean both short term and long term alterations of the project concept, and change some of the prevailing opinions on how projects should be run. On the other hand such new thinking seems to be more and more accepted, and should therefore be included to the extent that it is possible in future project system modeling.

5.3. A PRELIMINARY "TOTAL PROJECT DYNAMIC MODEL"

5.3.1. The "Total Project Dynamic Model" as it is at this stage of development, is presented in Appendix A. A further specification of the system's or the model's many stocks and flows of physical quantities (like workers) and information (like benefits or experience) and their relationship is still ongoing. But the main features are more or less completed.

The further extracting of empirical material from the database of 120 projects is also still in process. But part of it has already been possible to include in the model, giving at least the following important observations which coincides well with the thoughts presented earlier in this paper on some of the prevailing principles of good project conduct:

1. Projects are probably more dependent on decisions taken by adjacent authorities as Steering Committees, Advisory Boards, Base Organization Managers and Clients, than decisions taken "inside" the project. By letting the addition of resources both in respect of quantity and promptitude be a function of adjacent agencies "confidence" in the project staff, modelled as a function of how able the staff are to follow the original plan, very soon creates a typical "frustrated" model behaviour, pulsating between high "overproduction" and "underproduction" in task performance. Instead of having such agencies as stabilizing factors to the project, they soon become the real "unstabilizing" mechanism that strongly hurts the project progress.

2. Motivation plays a much more important role for the project performance than earlier models seem to have demonstrated. First of all team motivation, and team individuals motivation, seems to be affected by at least the following 6 factors:

a) The perceived progress or plan fulfillment
b) The final goal fulfillment
c) The milestone achievement or phase fulfillment
d) The rework discovery
e) The skill development
f) Adjacent bodies' confidence or their delegating willingness

Second, the effect of change in motivation seems to be fare more longlasting than previous models have suggested. This was discovered by using aggregated functions ("levels") explaining motivational behaviour, based on information indicated from the former data-base.

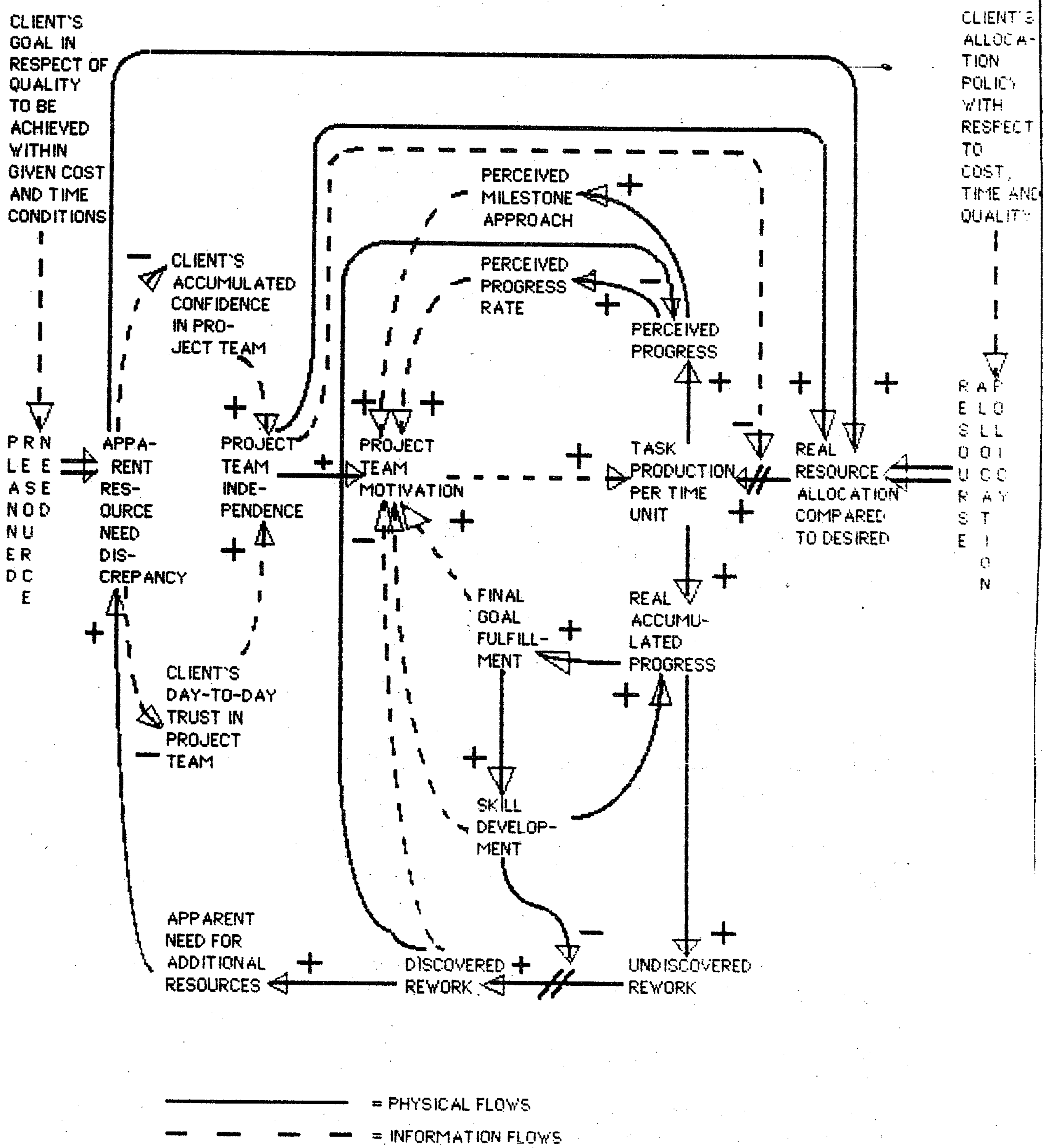
5.3.2. The model is now being expanded with among other factors, the introduction of

- Type of project
- Size of project
- Type of control system
- Level of initial staff experience
- Phase overlapping mechanism

5.3.3. Without persuing these model introductions in more detail at this point of time, it seems though valid to conclude that the existing theories of Project Management have multiplied and fragmented to the point were a new attempt of unification, employing the central notion of feedback, might be very productive. System Dynamics seems to fit the project approach very well because it antiquates the notion of the simple, linear, left-right causality as being the most representative for projects. An iterative, feed-back oriented approach to project management generates also better insights into the relationship between systems structure and behaviour, and those insights are, of course, the heart of the reason for building a project dynamic model.

6. APPENDIX A

Fig.1. CAUSAL-LOOP DIAGRAM FOR THE "TOTAL PROJECT DYNAMIC MODEL"



7. REFERENCES

Abdel-Hamid, T.K. The Dynamics of Software Development Project Management: An Integrative System Dynamics Perspective. Cambridge, Mass: M.I.T- Libraries, 1984.

Abdel-Hamid, T.K. and Madnich, S.E. Impact on Schedule Estimation on Software Project Behaviour, M.I.T., 1985.

Baker, B.N. and Murphy, D.C. Factors Affecting Project Success. Project Management Handbook by Cleland, D.I. and King, R.K. Van Nostrand Reinhold Co., 1983.

Belbin R.M. Management Teams. W.Heinemann Ltd. London, 1981.

Cleland, D.I. Graduate Management Education for Project Managers. Project Management Journal, August 1984.

Cooper, K.G. Naval Ship Production: A Claim Settled and a Framework Built. Interfaces, Vol.10, No 6, 1980.

Erez, M.P.C. The Importance of Participation on Goal Acceptance and Performance: A Two-step Model. Academy of Management Journal, Vol 28,1,p.50-66, 1985.

Forrester, J.W. Industrial Dynamics. Cambridge, Mass. The M.I.T. Press, 1961.

Gottschalk, P. System Dynamics Modeling in a Cable Manufacturing Corporation. Proceedings from the International System Dynamics Conference, Oslo, Norway, August 1984.

Graham, R.J. Project Management. Combining Technical and Behavioral Approaches for Effective Implementation. Van Nostrand Reinhold Co., New York, 1985.

Homer, J. Worker Burnout: A Dynamic Model with Implications for Prevention and Control. System Dynamics Review, No 1, 1985

Hout, J-C. and Cooper, K.G. Large Project Dynamics. 1981

Jessen, S.A. Project Management Handbook. The Norwegian School of Management, Bekkestua, Oslo, Norway, 1983

Joynt, P. The Value of Organizational Surveys. Working Paper 1986/15 Norwegian School of Management. 1986.

Katz, R and Allen, T.J. Project Performance and the Locus of Influence in the R&D Matrix. Academy of Management Journal. Vol 28, 1, p 67-87, 1985.

LBR. Totalprosjektering. Arkitekter og Tekniske Rådgivere, Sandvika, Oslo, 1986.

Mintzberg, H. The Nature of Managerial Work.

Morris, P.W. Managing Project Interfaces - Key Points for Project Success. Project Management Handbook, edited by Cleland, D.I. and King, W.R., Von Nostrand Reinhold Co., 1983.

Obradovitch, M.M. Management Problem Solving Seminars. El Segundo, 1976-1981.

Peter, and Waterman, .In Search of Excellence. 1982.

Richardson, P. and Pugh, A.L. Introduction to System Dynamics Modeling with DYNAMO. Cambridge, Mass. M.I.T. Press, 1983.

Roberts, E. A Simple Model of R&D Project Dynamics. R&D-Management, Vol. 5, No 1, 1974.

Schein, E. Organizational Culture and Leadership. Josey-Bass Press, 1985.

Smid, H. Changing Role of Management, HSM, Vol.6 (1), 1986.

Somers, I.A. A Causal-Integrative Model: A Management Tool for the Analysis of Cost Overruns in Major Systems Acquisition. University of Southern California, CA,LA, 1982.

Stephanou, S.E. and Obradovitch, M.M. Project Management. Daniel Spencer Publ., Malibu, CA, 1985.

Stuckenbruck, L.C. The Job of the Project Manager: Systems Integrator. The Implementation of Project Management: The Professional's Handbook. Reading, Mass.,Addison Wesley, 1981.

Takeutchi, H. and Nonaka, I. The New Product Development Game. Harward Business Review, No.1., 1986.