AN EXAMPLE OF HOW SYSTEM DYNAMICS CAN IMPROVE A NEW PRODUCT DEVELOPMENT PROCESS :MATRIX ORGANIZATION

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Abstract

This work aims to explain how applying system dynamics to the planning, control and management processes of R&D projects contributes to significantly improving such processes and thus enhances the success of the final outcome.

Introduction

All new product development processes (NPD) involve a wide range of factors -technical, human and organizational- which interact in an extremely complex way (Barclay, 1992); and so carrying out a R&D project is an extremely difficult and risky activity.

In this sense, it is fitting to point out that the configuration of a multifunctional team, as an Autonomous Team Structure (Clark and Wheelwright, 1993; 528-529) or Project Organizational (Roseneau and Moran, 1993; 124-125) encourages communication and informal relationships. Thus favoring the coordination and control necessary to be able to attain the threefold aim - speed, quality and efficiency- of any innovation project (Roberts, 1996; 66).

Nevertheless, having an interfunctional team involved in the project from the very outset is an essential but not sufficient requirement to efficiently plan the work to be carried out and in short, for the success of the project itself (Verganti, 1977).

Planning and Control Systems

For the R&D project to be successful -in the technical as well as the commercial sense-it is essential that its planning consists of an iterative and flexible process involving the participation of all the professionals who will later carry out the work. Furthermore, this participation will anticipate the future and identify the action routes necessary to attain the objectives proposed. Only in this way will it be possible to anticipate problems as opposed to being caught unaware by them (Badawy, 1997; 418-419), definitively reducing great part of the uncertainty associated with this type of activity (Rosenau and Moran, 1993; 74).

The carrying out of a planning process of this kind entails the use of positive feedback loops; as new information - of a technical and/or commercial nature - is continuously coming to light (Twiss, 1978; 389-390) which must be incorporated in the project and so changes must be updated regularity (Rosenau and Moran, 1993; 173). The use of this control form will not only enable the correction of the mistakes made by the decisions taken, but also lowers the possibility that such shortcomings might occur in the future (Mantell, 1973).

It is therefore necessary (Twiss, 1978; 407 and Badawy, 1997; 509 and 517) for planning and control to be part of a unified system; as both are closely related (1). Therefore, the techniques used in the initial planning of the project should also be the basis of its control; this control complements planning as its basic aim is to determine not where we are, but where we are going to (Badawy, 1997; 511-512).

If we take into account that system dynamics:

1. Aims to show how the problem detected occurred (Schroeder III, 1977; 246).

2. Allows each policy tested to be analyzed considering the different behavioral aspects it gives rise to; this enables the participants in the process to explore and understand the consequences of the approach or the action they propose (Pawson et al. 1995; and Radzicki, 1988).

3. Enables factors concerning the technical, human and organizational aspects to be included in the problem analysis; the latter two being incorporated thanks to the information provided by the people working in the system, whose mental models provide rich and accurate information about the problem and about how they interact

in order to take decisions to solve this problem, the system structure being configured in this way (2) (Eden, 1994).

4. Enables the involvement of the individuals who are going to be affected by the decisions in the decision —making process— which thus facilitates their acceptance (Jones and Deckro, 1993)-. In this way, the people involved in the project are given the option of refuting the merits of one another's ideas and assumptions at the same time as they are provided with a tool helping them to understand why a certain decision was taken and to identify the rules of the game (3) (Kim and Mauborgne, 1977).

Applying this methodology to the planning and management of R&D projects provides the possibility of combining a technical approach with the understanding of the complexity of modern organizations as socio-technical systems (Badawy, 1977; 99). This constitutes, due to the increasing complexity of technology, an essential requisite for efficient technology management.

In this way, it is possible that the members of the development team are faced with a "reality test", which forces them to think the project trrough, in enough detail, to devise some way to compelte it satisfactorily (Rosenau and Moran, 1992; 99). From this perspective, it is considered that the use of system dynamics in R&D project management enables three fundamental objectives to be obtained (Pawson et al.1995):

1. Reducing the "Time to Market"; that is to say, the time needed to design, develop and market the new product.

2. Helping to adapt new products to individual customer requirements; thus contributing to their commercial success.

3. Increasing the flexibility of the operational process, when faced with unforeseen events.

Use of the matrix organization in new product development

We go on to relate a brief example of how by applying system dynamics to R&D project management it is possible to analyze and even quantify —a priori— the effect that the different measures or decisions are going to have on the evolution of the project. In this way, it is possible to anticipate —before the implantation of such policies in the real system— the scope of their consequences and avoid the implementation of those policies which are revealed as destabilizing.

To this end, a model has been built reproducing the evolution of a design and development project for a new product —consisting of a single phase— made up of 26,000 tasks (4) . To achieve this a matrix team structure has been established made up of 10 workers and a deadline of 65 weeks (5) has been set.

Figure 1 shows how the team in charge of developing the new product is capable, in productivity terms (6), of performing a certain number of tasks each week (7). In this way, the number of completed tasks increases as the number of tasks awaiting completion decreases. Periodic forecasts are made which —on the basis of work pending and the time remaining until the project deadline date— will enable us to determine whether or not it is possible to finish the project by the initial deadline. When as a result of these forecasts, it is considered that the initial deadline is going to be overrun, a likely counteracting measure will consist in increasing the size of the development team; even resorting to contracting external labor.

The application of this policy will be accompanied by a certain delay as a consequence of the time needed to perform the selection and socialization processes of the new employees (8). In this way, a negative loop is generated —Figure 1— which increases the quantitative stability of the development team and so brings the project closer to its end.

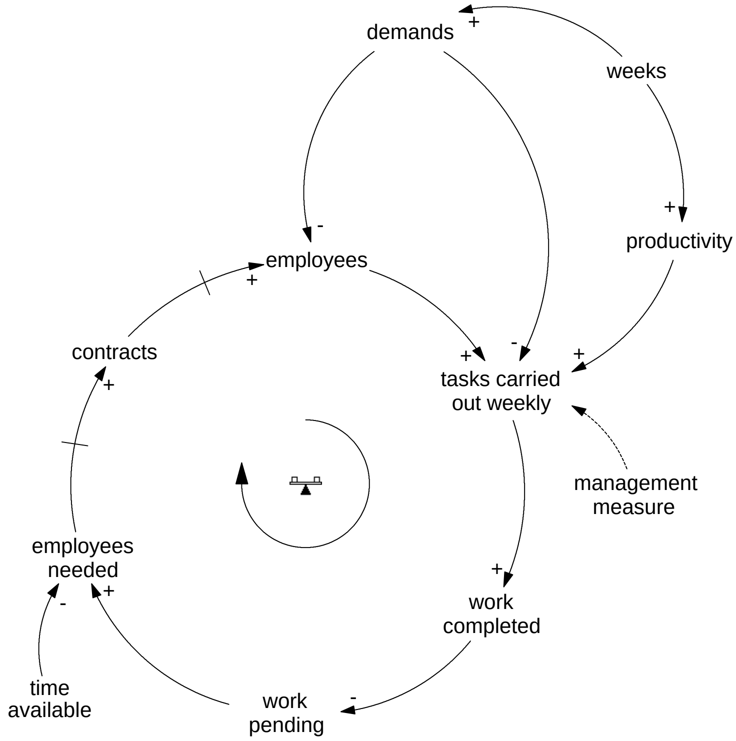


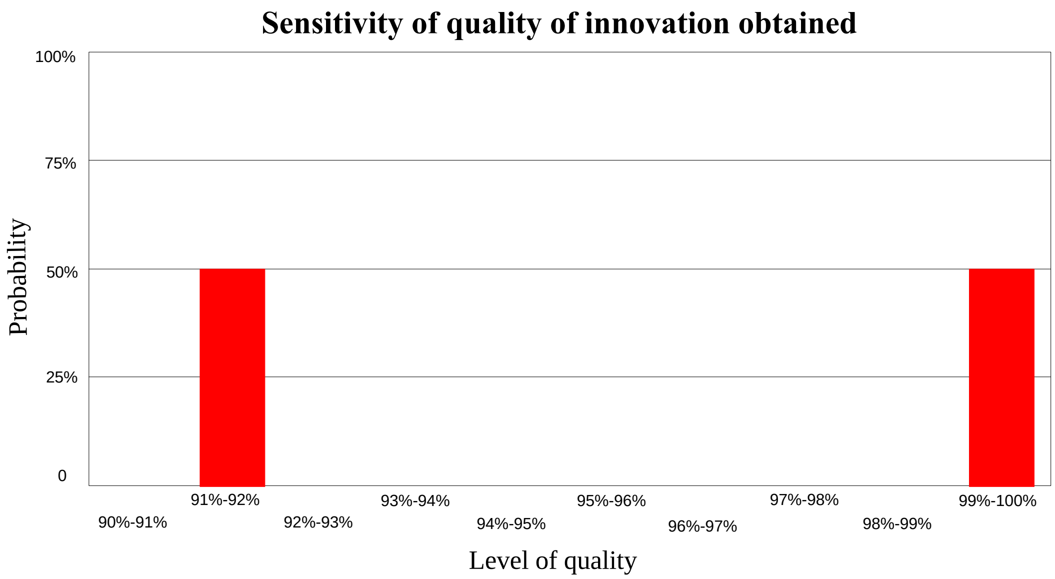
Figure 1: Loop including the performance attained by the development team

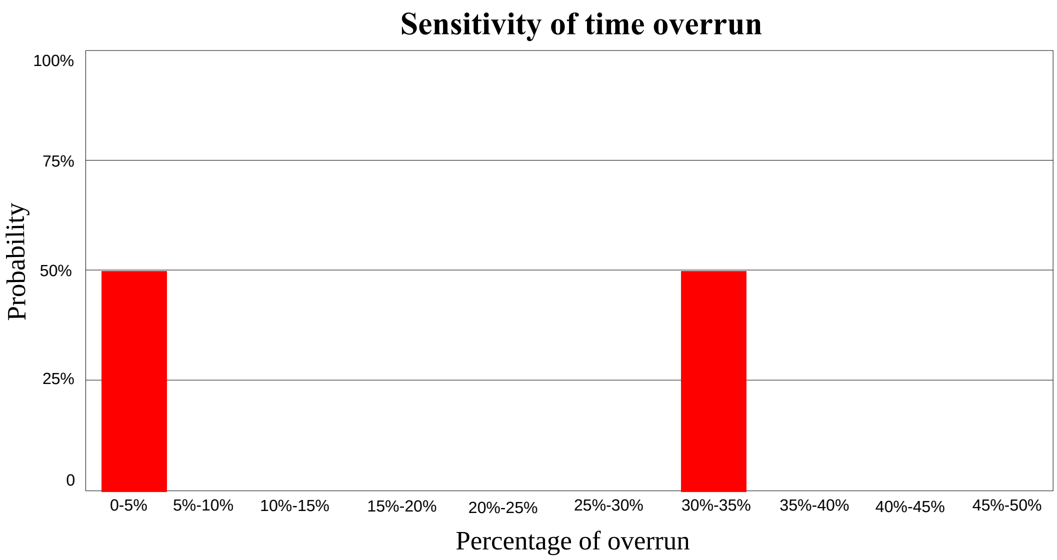
However, insofaras throughout the project, demands are made from all the functional areas for the various team members to be reintegrated in their respective departments (9) and these requests are heeded, this will cause lower productivity as a consequence of reducing the size of the team as well as damaging the team spirit and commitment of its members to the project objectives.

Once the rest of the loops making up the model have been configured (10) and the relations between their variables converted into a mathematical model, we proceeded to carry out a series of simulations-using the software program VENSIM 3.0A. One of the most significant results of these is as follows:

Simulation results

A sensitivity analysis was performed in order to assess the impact of the previously mentioned demands on the threefold project aim; obtaining the results shown in the following three graphs.





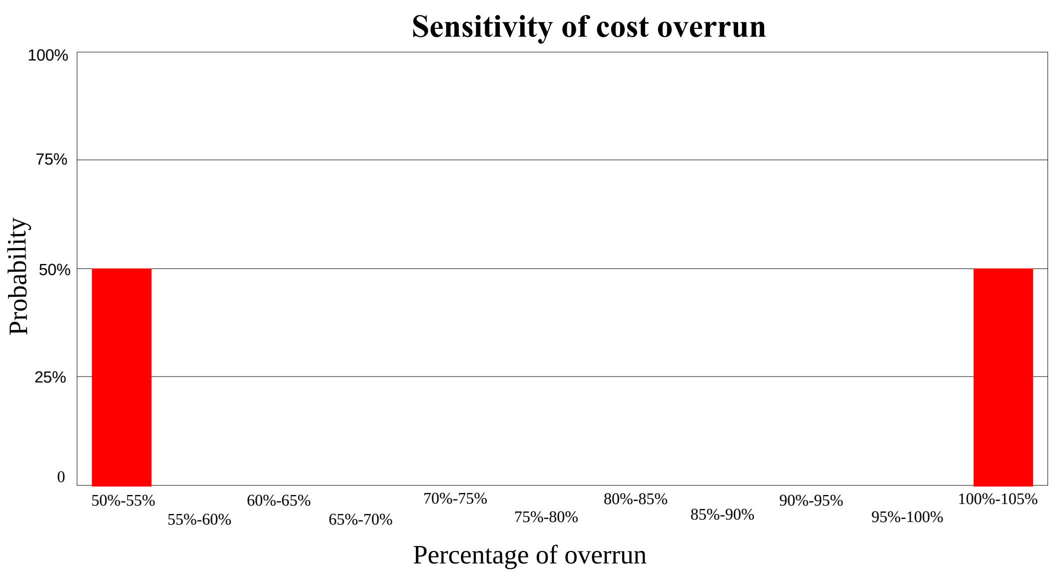


Figure 2: Graphs of sensitivity analysis

Just as can be seen in each of the three graphs in Figure 2, very significant improvements are obtained in each of the three dimensions of the set objective- quality increases from a value lower than 92% to almost 100% (11); whereas the time overrun decreases from 30-35% to less than 5% ; the financial overrun also decreases from more than 100% to less than 55%. Such improvements are much greater than those which can be obtained as a result of the modification of any of the other factors intervening in the project and which are controllable by the firm.

The increase in effectiveness and efficiency is the consequence of the greater performance attained by the group when such demands are not made or when they are not heeded —Figure 3—. The department heads usually consider the members of the development team as mere representatives of their departments in the NPD process. For this reason they do not attach great importance to recalling these workers when their experience is required in their respective functional areas. However, for the team itself these recalls are a great loss; as a good part of the essential knowledge of a project development team lies in the view points and shared experience which the team members have generated over a long period of time.

Therefore, the fact that the project manager enjoys a certain status in the organization, higher than the functional managers is of great importance; hence this will enable him to ignore such demands. In this way, the claims will not be able to affect the development team either quantitatively or qualitatively nor diminish its weekly performance as a consequence of the reduction in size and the weakening of its commitment the proposed goals.

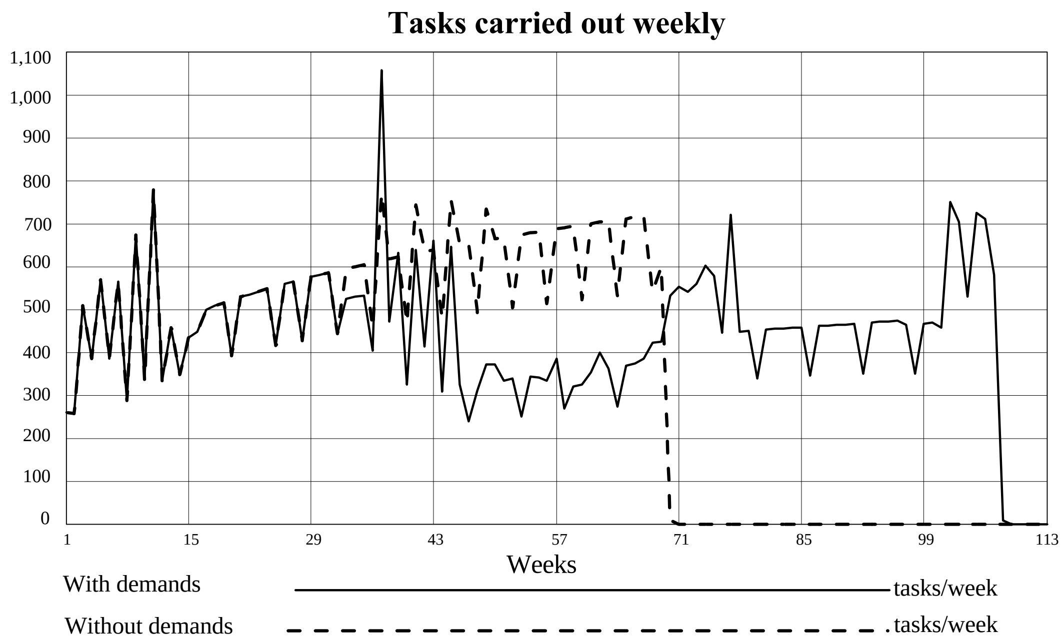


Figure 3: Graph comparing the number of tasks carried out weekly

Conclusions

This paper has attempted to summarize the application of system dynamics to the planning and management of R&D projects, enabling the assessment - before their effective application- of the impact that certain organizational practices are going to have on the evolution of the work and its final outcome.

By way of example, we have explained how by means of the simulations made with a dynamic model, it is possible not only to corroborate the affirmation made by Twiss (1978; 411) concerning: " the possibility that unforeseen qualitative or quantitative changes in the composition of a development team, will have a negative and disproportionate effect on group morale; this having repercussions on the finishing of the product, cost increases and significant loss in quality"; but it is also possible to quantify the repercussions of these changes.

Notes

(1) This is so, insofaras the plan indicates how the project is expected to turn out, the feedback providing information as to what extent the actual project performance fits this plan. Finally the control, by comparing both aspects, gives rise to a series of decisions and acts, by which it is aimed to improve the future orientation of the project.

(2) Mental models, despite being very rich in content (Radzicki and Seville, 1993) have however little capacity for accurately tracing the dynamic behavior inherent in their structure as the system presents circular and accumulative behavior patterns which are counterintuitive; hence, it is necessary to perform a simulation process.

(3) A fair process is thus configured, which gives rise to trust and commitment. These, in turn, produce voluntary cooperation which leads to performance and causes the team members to share their knowledge and apply their creativity.

(4) These are interrelated by means of a nonlinear precedence relationships represented by means of a graphic function which offers five possible alternatives-minimum, low, moderate, strong and definable-.

(5) Extending this to 16 weeks more is considered acceptable to thus include the changes produced in the project as a consequence of the uncertainty inherent in this type of activity.

(6) This, unlike what is generally established by static orientation techniques will continue to be modified throughout time, thanks to the greater level of group integration and to the strengthening in group commitment to the project.

(7) The time interval set for the simulation has been the week.

(8) Should the new additions to the team come from different departments within the firm, the selection process will be replaced by internal search and authorization processes.

(9) The probability that these requests are made will increase with the passing of time; as it cannot be forgotten that the development team is configured as a temporary structure.

(10) All the feedback loops which determine the structure of the system and its behavior, as well as the flow diagrams and their corresponding equations are not included in this work due to the limited number of pages per communication.

(11) The design and development process of a new product aims to achieve 100% quality; as should the slightest design defect be tolerated, this would result in a 100% defective production.

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