

SYSTEM DYNAMICS MODELING FOR
LONG RANGE STRATEGIC PLANNING

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ABSTRACT

A system dynamics model of a major telecommunications network has been developed to support managers in the function of long range strategic planning. Application of system dynamics to the strategic planning area was found to be, in some respects, quite unique. The article discusses this type of application in the areas of model requirements, sponsorship, scope, development, and review.

In the area of requirements, it was found that a system dynamics model developed to support long range strategic planning should be quite broad in scope, must satisfy a potentially large community of planners, yet also must pass the review of tactical planners as well. A baseline-model approach is proposed as an effective way to satisfy these requirements. Guidelines for the modeler are proposed for obtaining sponsorship, for avoiding pitfalls in the model development process, and for interacting with model users and reviewers. The baseline-model approach, coupled with the guidelines, has been found to work quite effectively within one organization to support long range strategic planning.

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A system dynamics model of a major telecommunications network has been developed at the Jet Propulsion Laboratory. Its purpose is to support the management function of long range strategic planning for the roughly \$100 million per year network. The application of system dynamics modeling to the area of strategic planning is not a subject heavily represented in the literature, and the team developing the above Telecommunications Network (TN) model found that such modeling is in some respects quite unique. The following sections describe these unique aspects as they are found in the areas of: requirements for system dynamics models in the long range strategic planning environment (Section I); sponsorship for such models (Section II); model scope (Section III); model development (Section IV); and interaction with users and reviewers (Section V).

I. Requirements

According to George A. Steiner, the strategic planning process is the formulation and implementation of strategy.[1] He further refers to Peter Drucker for the definition of strategy formulation as:

"the task of thinking through the mission of the business, that is, of asking the question 'what is our business and what should it be?' This leads to the setting of objectives, the development of strategies and plans, and the making of today's decisions for tomorrow's results. This clearly can be done only by an organ of the business that can see the entire business; that can make decisions that affect the entire business; that can balance objectives and the needs of today against the needs of tomorrow; and that can allocate resources of men and money to key results." [2]

Drucker's definition adequately captures the purview of the long range strategic planning organization for which the above model was developed. Implicit within this definition are the following characteristics of strategic planning organizations:

1. The viewpoint of the managers is quite broad, encompassing up to the entire system to be planned.
2. The planning horizon is correspondingly long. In the case of long range strategic planning of the author's experience, the planning horizon is ten to fifty years.
3. The amount of planning work involved is substantial and, thus, a number of managers can be heavily

involved in the planning process. This was indeed the case for the TN model where the group of managers involved in strategic planning included up to fifteen individuals.

4. A strong connection may exist between the strategic plan and the tactical plan for detailed implementation. The managers of both strategic and tactical concerns will thus be quite interested in any tool used to support long range strategic planning.

Any successful system dynamics model developed for a strategic planning organization must deal effectively with the above organizational characteristics. The author's group found that the long range strategic planning environment and organizational characteristics uniquely affect the modeling effort in three ways:

1. It is quite difficult to limit the focus of the model to one or two questions. As stated by Jay W. Forrester; "The model must reflect the point of view of the person whose questions are to be answered by the model experimentation." [3] In the case of long range strategic planning, the viewpoint is quite broad and the persons many. This will be discussed further in Section III.

2. There may be a substantial number of potential users of the model.
3. There may also be a good number of people who will review the model, even though they are not users.

Thus, the requirements of the model include: that it be useful for long range strategic planning, that it be quite broad in scope, that it satisfy a substantial community of strategic planning users, and yet that it also pass the review of tactical planners as well.

II. Model Sponsorship

As stated by Steiner;

"Years ago, the managerial emphasis in the typical corporation was on operations. A major question for management was how to use effectively those scarce resources at its disposal in producing goods and services at prices consumers were willing to pay. ... Today, efficient use of scarce resources is still a commanding concern of managements of all organizations, but today, because of a turbulent and rapidly changing

environment, the ability of an organization to adapt properly to environment, internal and external, is becoming more critical in survival."[4]

Thus, in the terms of A. Porter, the recent emphasis in organizational planning has moved from "optimization" to "adaptation,"[5] and this change is in response to an increasingly dynamic environment.

As most proponents of system dynamics would agree, this need for adaptive (or strategic) planning is eminently suitable for application of system dynamics. Yet, some managers will question the ability of any model to capture a quickly changing environment, much less address the equally dynamic company plans. An effective strategy for a modeler to pursue in this case is as follows:

1. Find the strategic planner who is at least willing to grant the benefit of the doubt to the ability of system dynamics to cope with such a situation. Use this person or person(s) as the foundation of support.
2. Build additional support slowly. Once the model is developed and approved, use it to first address questions that are of medium, rather than extreme concern. Once confidence in the model is

established with respect to these medium-concern issues, the community of managers will be more likely to seriously apply the model to higher-impact planning issues.

It is of interest to note that an organization being subjected to major upheavals is not likely to have the management time to devote to developing a new system dynamics model, even though such could be of extreme value. Yet, if the organization already has such a model, a few enhancements might very well enable the manager to model the effect of recent perturbing changes under various policy scenarios. This can be a major selling point to a set of prospective sponsors.

III. Model Scope

It has been stated numerous times in the system dynamics literature that a system dynamics model must be developed to address a single issue or question for the model to be focused and for the effort to be productive. John D. W. Morecroft claims: "The point of departure for any strategy support modeling project is a clear definition of the strategic problem at issue . . ."[6] Jay W. Forrester states: "The first guiding principle is to state a clear purpose. One

should at first identify the problem, the phenomenon, or the question to which the model is to be addressed."[7]

The opposite extreme of a single-issue or single-problem model is the general purpose model, of which Edward B. Roberts says:

". . . most [corporate] models were not built to solve a problem; they were instead built merely to represent (or simulate) a corporation. If you build general-purpose corporate models, you should assume in advance that you will achieve little or no implementation of results. You must build models that are motivated by a real problem that exists."[8]

Unfortunately, a single-issue model, if not impossible, is not as productive as a more general model when applied to the area of long range strategic planning. The reasons are as follows:

1. There are numerous managers likely to be involved in a model designed to support long range strategic planning.
2. These managers can have quite a broad view of the system to be modeled.

3. Each manager has one or more issues that need to be addressed, and the overlap among managers is not total. In fact, most planning organizations delegate planning areas to different managers both to accomplish more and to gain the advantage of multiple viewpoints.
4. Two common questions asked by a strategic planner of a system dynamics model are: How does the real system work, and what behavior does the system produce? Yet, these are the very questions that the single-issue modeling approach singles out to be avoided.
5. Ultimately, credibility in the model and belief in its usefulness can not be easily achieved with a single-issue model. The multiple users and reviewers of the model will claim that such a model is too limited, addresses issues unimportant to them, is too expensive per result obtained, and is too incomplete. Even if the model is built for a single, strategic planner with a single issue in mind, to implement the strategy effectively that planner must have cooperation of the others in the area. They too must be convinced of the model's completeness and veracity.

It is not impossible to build a model broadly satisfactory to a strategic planning organization in a single-issue fashion -- it is just less likely. Basically, the model must be broadened one issue at a time, with critics at the door each time a recommendation is made. The author's group came to the conclusion that in such a mode, the model would very likely be shelved before its full potential could be demonstrated.

There is actually evidence in the literature supporting such a conclusion. Roberts states: ". . . the problem or opportunity you select has to be seen as important to the 'client' of your project, whom I define as the individual or small group whose approval is needed for change to be implemented." [9] In the case of strategic planning, a single issue satisfying this criterion is not common. Roberts even notes that after proceeding with a model built in the single-issue mode, a problem may occur in which a recommendation on the issue has unexpected effects on another part of the system. He states that the question must be asked: "Will this recommendation impact other systems or other parts of the system?" [10] This is a question quite likely to be posed by critics of a single-issue model at the point of recommendation. These critics are likely to be managers of other parts of the system who were not overly involved in the

development of the single-issue model. Even Jorgen Randers, who warns of the "tendency to ramble due to lack of an explicit goal,"[11] recommends that if the complexity of the model must be reduced, that the modeler should "reduce the amount of detail (depth), rather than scope (breadth). . . ."[12]

An alternative to the single-issue modeling procedure is proposed as follows:

1. Develop a more general model of the system, where the system is defined as the entity planned by the strategic planning organization. This more general model, which can be referred to as the baseline model, should incorporate the variables and parameters of interest to the strategic planners (thus capturing the system reference mode) and specifically address: How does our system operate; and, given the existing set of conditions, policies, and plans, how does it behave? This baseline model does not have to be huge, just comprehensive. The TN model uses roughly 600 DYNAMO instructions.
2. During the development process, maintain a list of questions the various managers do want answered.

This list will help the modelers incorporate the proper parameters, and when prioritized, the list will supply a roadmap for the enhancement phase.

3. Subject the baseline model to critical review. Testing the ability of the baseline model to address some of the managers questions will be a test of its completeness. Yet managers will not expect the baseline model to answer all questions.
4. Enhance the model, once approved, to address other questions.

The advantages of the above procedure are respectable. The baseline model can describe the real system and system behavior. In baseline form, it can thus be used to identify areas in which managers of the system disagree, provoke discussion of strategic planning issues, and stimulate strategic thinking in new areas by virtue of its breadth. If the modelers are even somewhat careful, the baseline model can also address significant managerial problems even before enhancement. When the baseline model is done, the enhancements require less time because the system structure already exists and is approved. In this mode, the model is less likely to be used just once and shelved, and as a model of the whole system, it becomes a reference point for new strategic planning. Enhancements are built and the model

becomes a thriving, evolving representation of the dynamic system that it models.

All, however, is not roses. The founder(s) of the model must be willing to wait longer for the baseline model than they would for a single-issue model. This process can only be expedited to the degree that the many necessary people can be interviewed, that the separate observations and perceptions can all be combined in a single consistent model,¹ that the data can be obtained, and that the reviewers can all be brought together as required. Yet, the result is worth the effort in the case of a system dynamics model for long range strategic planning.

IV. Model Development

In the area of model development, there are a few guidelines that, while true for any system dynamics model, are also especially relevant to a strategic planning model. The first is a point noted by Roberts, that "To the maximum degree

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1. Consistent is used here to mean that the model presents a single, rather than multiple, representation of the system. The baseline model can of course include system inconsistencies if such exist in the real world.

possible, the work should be executed by knowledgeable in-house employees." [13] Following this procedure was indeed found to be quite effective, after the initial requisite training in the system dynamics technique. The second guideline, also noted by Roberts, is that "The effective model will contain a level of detail sufficient to demonstrate the problem system, and sufficient to persuade participating management of the model's adequacy." [14] H. B. Weil agrees, saying ". . . clients are more comfortable with and confident in a model that they consider 'realistic.' Since these attitudes are an absolute requisite for successful implementation, we are generally very accommodating to client desires for more detail." [15] In the case of long range strategic planning, the "problem system" mentioned by Roberts may be the entire system being managed, and the level of detail required may well be the baseline model as described in Section III.

In addition to the above, there are warnings issued by modelers in other areas that are equally applicable to modeling for long range strategic planning. Even with the baseline model approach in mind, as proposed in Section III, the following are common ways in which the modeling effort can get sidetracked into interesting, but potentially deadly paths:

1. Building the model to answer tactical rather than strategic questions. Even though the tactical planner may have some review authority over the model, it should be made clear that the model is designed for strategic, not tactical, use, as they are quite different in detail, boundaries, and time horizon.
2. Overdevelopment of the model sector(s) best known to the modelers. This is extremely difficult to combat, as it is most certainly a part of human nature.
3. Overdevelopment of the model sector(s) best known by the model's strongest supporters. Use of system-level reviews helps to minimize this tendency.
4. Starting a new system dynamics modeling effort before completing the current one. An excruciatingly obvious trap, but nevertheless quite powerful when a new system appears on the horizon, just begging for some system dynamics analysis.

The modeler can most effectively deal with these sirens of the modeling world by being aware of their existence and wary of their song.

V. Users and Reviewers

As noted above, using system dynamics to support long range strategic planning may involve the review and/or approval of the baseline model by quite a few individuals. These individuals can be roughly categorized as follows:

1. Those funding the effort.
2. Those whose approval is required before a recommendation can be implemented.
3. Those whose review is required as an input to those approving in 2.
4. Those who are interested for their own reasons and whose good will is helpful, if not absolutely necessary.

Clearly, most effort will be spent on satisfying the first two categories of individuals; however, none should be neglected or alienated. Even more challenging, these multiple users and reviewers will undoubtedly have multiple and disparate views of: the system, current plans, current policies, strategy changes, effects of strategies, and evaluation of effects. This is probably inherent in the nature of strategic planning and the managing of a complex system. Yet, it is difficult to please everyone.

The author's group has found a few techniques to be of use in interacting with users and reviewers during this process. They are as described below.

1. Use the same review process and documentation as employed for other strategic planning efforts. The users and reviewers will be most comfortable with this known approach, and if approval is achieved, the model's recommendations have a greater chance for successful implementation.
2. Within the above review format, be sure to include background on those items peculiar to system dynamics, as is well discussed in the literature.
3. Employ a varying review audience: use the full user-reviewer audience when you want broad comment and critique; and use a more limited audience for review of specific parts of the model. Similar to the process of gradual validation testing, confidence in the model can be built with a series of iterative reviews by slightly varying audiences.
4. Be ready to respond to the query: "But how can you possibly test such a model?" Keeping a list of the

standard system dynamics tests, and the status of the model with respect to each, has been found to be quite effective.²

5. Be ready to compare the system dynamics technique to standard econometrics techniques. It is not uncommon for someone familiar with modeling in general to impugn your model for those very difficulties that system dynamics was created to alleviate.
6. Do not be discouraged in the need to repeat yourself with respect to the model and the technique. The user may need to repeat views to you too in the process of evolving a model in the environment of multiple users and reviewers. A combination of Working Memoranda, as suggested by R. G. Coyle[16] viewgraph presentations, viewgraph reviews, and individual conferences are effective in supporting good communications.

2. This technique was suggested by Dr. Peter C. Gardiner, University of Southern California.

Once the baseline model is reviewed and approved, the model can be applied by either the modeler or the user to answer policy questions. As stated earlier, some questions will require enhancement by the modeler. Yet with a fully discussed and approved baseline model, the policy analysis proceeds more smoothly. The dialectic method of strategy analysis and selection, as proposed and well supported by John D. W. Morecroft, is quite applicable in this stage. In his words, the model will be "a vehicle for extending argument and debate . . ."[17] to arrive at a new or changed system policy.

VI. Summary

The application of system dynamics to the area of long range strategic planning has some unique aspects. Such modeling will involve a large audience, members of which will contribute to the model, review the model, and use the model. To adapt to this larger audience, an approach is proposed in which a more general model of the system, called the baseline model, is developed and approved. This baseline model is then selectively enhanced as necessary to address more user questions.

This approach, together with guidelines and experiences outlined above, has been found to work quite effectively within one organization to support long range strategic planning.

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