

STRATEGIC PLANNING BASED ON AXIOMATIC DESIGN

Fredrik Engelhardt

fredrik@mit.edu

Visiting Scholar

Department of Aeronautics & Astronautics
Massachusetts Institute of Technology

Dr. Mats Nordlund

mats.nordlund@saab.se

Saab AB

Sweden

ABSTRACT

This paper describes how to use Axiomatic Design to create and plan a company-specific strategy. It could, for instance, be a technology strategy plan, or a business plan. It is shown that using axiomatic design during the strategic planning process achieves a tight relation between company goals (i.e. functional requirements in the design language), company strategies (i.e. design parameters), and activities (i.e. process variables).

When using Axiomatic Design it is possible to do an optimization of the implementation process, i.e. action plan, by solving the mathematical system represented by the design equations. Such an optimization of the action plan minimizes iterations and speeds up the implementation process. Tasks that can be performed independently of other actions are identified and are implemented immediately without considering inputs from other process steps.

The approach described is tested and verified in case studies performed within large industrial companies. The results are implemented in industrial practice.

Keywords: Strategy; Process planning; Business Planning; Technology strategy; Axiomatic Design

1 MOTIVATION

It is important for a company to have clearly stated goals and visions, and to perform tasks accordingly. A strategy links the company's goals and visions with performable tasks. A company that uses a well-defined strategy can achieve its goals faster than if the work was carried in a less structured manner. Some examples of the effects of a tight coupling between what the company aims for, and what it actually does are: (1) less resources needed for achieving the goals, (2) selection of proper technologies for chosen markets, (3) hiring procedures focused on getting the employees needed for planned tasks, (4) motivated employees that know the reason for what they are doing, etc. (see for instance Senge, 1990).

A strategy improves the competitive advantage of a company (see for instance Ghemawat, 1991; Hax and Majluf, 1996; McGrath, 1995; McGrath, 1996). The strategy has to be consistent all the way from high-level company goals and visions, down to the actual tasks carried out by the employees. The strategy also has to be customized for each company. The company's organization, culture, and area of business all provide

company-specific needs. Those needs have to be taken into account when *designing* a strategy.

Tools are needed that improve both designing of the strategic content, and the strategy process. This arises from three strategy-related problems that are common and important to address: (1) Too many strategies lack action plans to fulfill their high-level goals (Nordlund, 1996), making these strategies diffuse and difficult to realize. (2) There are very few tools for customizing and designing a strategy to a company-specific and detailed level. (3) Strategy related processes are seldom analyzed and iterative loops between organizational units can often continue for a very long time without bringing the projects closer to their goals.

In this paper we suggest the use of Axiomatic Design as a tool for tackling the problems stated above. Axiomatic Design can be used to design strategies that suit specific companies, and at the same time ensure that goals and visions have related action plans. By using Axiomatic Design as a strategy tool it is also easy to determine the optimal arrangement of the action plan's process in order to reduce iterations and thereby improve speed.

2 RELATED WORK

2.1 FRAMEWORKS FOR STRATEGIC PLANNING

Many approaches as to what should be implemented in a strategy are suggested in management literature. Eight of the more influential ones are: (1) Porter's five market forces for evaluating market attractiveness (Porter, 1980); (2) The value chain analysis and its nine activities for increasing customer value (Porter, 1985); (3) Improving competitive advantage by focusing on core competencies. Core competencies are resources that are sources of competitive advantage, they can be expanded to many applications, and a core competence is hard for competitors to imitate (Prahalad and Hamel, 1990); (4) Ghemawat's model of how to achieve competitive advantage by addressing large and important decisions by looking at positioning analysis, sustainability by commitment to *sticky factors* (i.e. untradable, specialized, and durable) that are scarce and accessible, as well as looking at the level of flexibility (Ghemawat, 1991); (5) Achieving high performance by setting a strategy for high-level stakeholders and then adjusting it to fit important business processes, resources, and the organization (Erickson and Shorey, 1992); (6) Corporate headquarters should plan and define the corporate mission, establish strategic business units, assign resources to each strategic business unit, and plan new businesses (Kotler, 1997); (7) Strategic matrix models that suggest generic strategies depending upon the level of market growth rate and

relative market share, or market attractiveness versus business strength (Kerin et al., 1990); (8) The insight that a strategy has to be successfully implemented and therefore is co-dependent on the company's structure, systems, style, staff, skills, and shared values (7-S framework from Peters and Waterman Jr., 1982).

The strategies and processes suggested in literature are to some extent contradictory, and focus mostly on high-level decisions. Some researchers praise the concept of strategic business units (see for instance Hax and Majluf, 1996), whereas others prefer core competencies as an alternative way of organizing the company (Prahalad and Hamel, 1990). Some of the mentioned techniques also stress that a strategy has to be applied at all levels of the company, but few suggest how this should be done.

Also, the references referred to above focus on both the strategic *content* and to some extent on the strategic *process*. The process of implementing the strategy is an important step. Hax and Majluf (1996) provide a strategic framework and a process for this framework. A corporate strategy is first set in place, then a business strategy is defined that uses the corporate strategy as input. The business strategy is further enumerated into functional strategies by combining business-internal functional scrutiny and a functional environmental scan. Strategic budgeting and planning follows the functional strategy. There are some software applications available to support this process.

The Design Structure Matrix (DSM, see for instance Eppinger et al., 1994) is another tool for evaluating processes and information flows in organizations that has attracted much research interest during recent years. A DSM can be used to evaluate information flows in processes and thereafter to indicate areas of organizational/process changes that decrease development time by reducing iterations.

The DSM approach does not specifically support the actual *designing* of the process or the strategy.

A strategy has to be customized for each company. This is clearly stated by Kotler, who notes that: "Goals indicate what a business unit wants to achieve; strategy is a game plan for how to get there. Every business must tailor a strategy for achieving its goals" (Kotler, 1997; p. 84).

Tools for customizing, or *designing*, the strategy to fit companies at all levels are less frequent in management literature.

2.1.1 AXIOMATIC DESIGN

Axiomatic Design can be used as a tool for the *design* of non-engineering design objects, such as technology strategies, business plans, and organizations (Engelhardt, 1998; Nordlund, 1996; Suh, 1990). Axiomatic Design is a principle-based design method focused on the concept of domains (Suh, 1990). See Figure 1.

Axiomatic Design addresses in particular the internal relationships between a product's components.

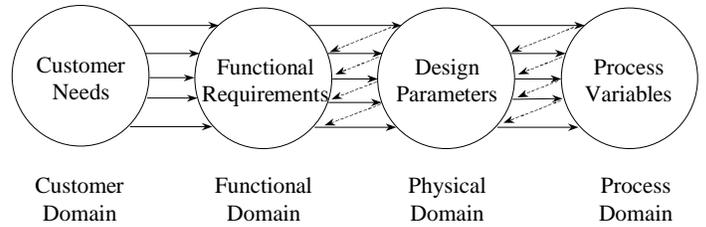


Figure 1. Design domains in Axiomatic Design.

When designing with Axiomatic Design, a mapping between high level requirements and their solutions is detailed through a zigzag process. The mapping is often performed between domains containing functional requirements (FRs) and design parameters (DPs) but could also be done between domains containing design parameters (DPs) and process variables (PVs). This mapping process can be represented as Figure 1, and is described by the design equation with its Design Matrices (DMs):

$$\{FR\} = [DM]\{DP\} \quad (1)$$

where

$$DM_{ij} = \frac{\partial FR_i}{\partial DP_j} \quad (2)$$

There are guidelines, provided by Axiomatic Design theory (consisting of axioms, theorems, and corollaries), about the relationships that should exist between the different domains. These guidelines answer the question—will a set of design parameters (DPs) satisfy the functional requirements (FRs) in an acceptable manner? These relationships should also hold between DPs and process variables (PVs). The links between customer needs and FRs, however, are more loosely structured. The guidelines for Axiomatic Design theory originate from the two design axioms:

Axiom 1: The Independence Axiom (Maintain the independence of the FRs)

Axiom 2: The Information Axiom (Minimize the information content, i.e. chose the solution with the highest probability of success)

To transform Axiomatic Design into a tool for strategic design, the FRs are renamed "goals", the DPs become "strategies", and the PVs are translated to "activities" (Engelhardt, 1998; Nordlund, 1996). Customer needs remain customer needs. See Figure 2. Customers could be stakeholders, as well as internal or external customers. See Figure 3.

activities and strategies that affect anything other than their corresponding goals are avoided if possible.

It is easy to create an implementation plan (i.e. process plan) once the Design Matrices are set up for the chosen strategic design. This implementation plan minimizes iteration since it is derived from solving the equation systems described in the Design Matrices. The equation systems from the Design Matrices express how the parts of the strategy are interrelated.

It is important to define a theoretical input, as well as a foundation for the company's preferences, when designing a strategy. Since there are many ways of satisfying various stakeholders these preferences may differ. One may choose to compete by excellence in quality, market service, development speed, or low price, etc.

This paper focuses mainly on two aspects of strategic design, how to (1) design the strategic *content*, and (2) design the strategic implementation *process*.

3.1 DESIGNING THE STRATEGIC CONTENT

The process of designing a strategy with Axiomatic Design can be described with a control feedback loop. See Figure 3.

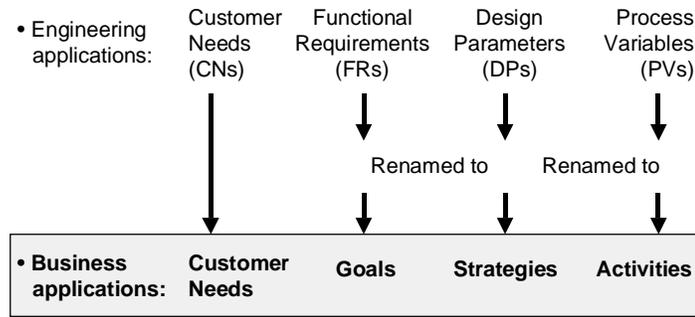


Figure 2. Axiomatic Design applied to the design of strategies.

The interpretation of the fundamental design axioms in a strategic planning context then becomes:

Axiom 1: The Independence Axiom (Maintain the independence of the goals)

Axiom 2: The Information Axiom (Minimize the information content, i.e. choose the solution with the highest probability of success)

To display the design solution between, for instance, the Functional Domain and the Physical Domain, a goal-strategy tree is used (for the similar function-means tree see for instance Andreassen, 1980; or for comparable early versions Marples, 1961). The very similar FR-DP-tree (Suh, 1990) can also be used. For examples of goal-strategy trees see Figure 4 and Figure 6.

3 STRATEGIC PLANNING BASED ON AXIOMATIC DESIGN

The use of Axiomatic Design as a tool for strategic design and planning guarantees a strong relationship between the goals and the strategies defined. Strategies determine the preferences that the designer (i.e. the company) thinks are necessary to fulfill the goals. The activities are tasks and actions that enable a successful execution of the strategy.

Since Axiomatic Design is a top-down design method, it is very suitable for consistently transferring high-level company goals and visions down to specific projects. This breakdown of abstract goals into more concrete ones improves company efficiency (Robbins, 1994). It also allows the firm to more rapidly adopt a new strategy by relating how low-level goals and strategies as well as tangible activities relate to overall strategic vision, which improves employee participation and communication.

Using Axiomatic Design as a tool for strategic planning minimizes contradictory and overlapping goals, strategies, and activities. Axiomatic Design helps the designer set up design equations that express the relationships between goals, strategies and activities. The framework provided by Axiomatic Design stresses simplicity by having a one-to-one mapping between activities, strategies, and goals. Strategic designs solutions having

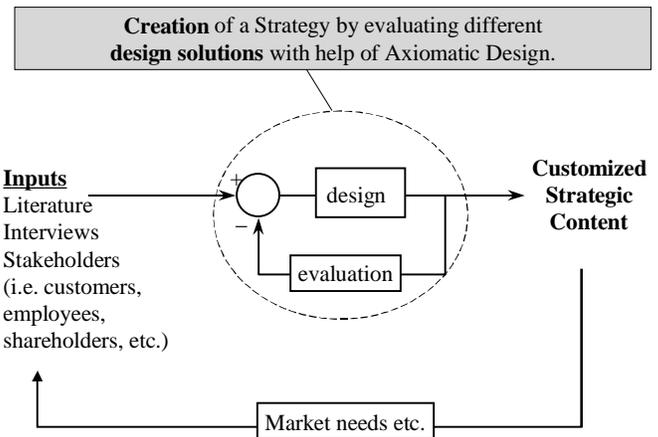


Figure 3. The design process (based on Suh, 1990).

The inputs from the stakeholders form preferences that guide the designing of the strategy. It is therefore important to define the inputs to the design process when designing a company specific strategy. Some inputs could be: What are the high-level preferences of the company? What is the Weighted Average Cost of Capital that the shareholders demand? Are some core competencies and core businesses defined or is that up to the designer to find out? Who are the customers? What are their opinions? What theoretical foundation do we choose for the company's strategy (i.e. do we use core competencies, the commitment framework, or classical strategic business units etc.)?

Designing with axiomatic design consists of setting up high-level goals, according to the company's preferences (i.e. stakeholder Needs). Then corresponding strategies are defined to fulfill these

goals. High level goals and strategies are decomposed into more detailed sub-goals and sub-strategies. Emphasis is placed on how different strategies affect other goals. The importance of incorporating the voice of the employees when defining the input for the design process is further discussed in Akao (1991), Senge (1990), Deming (1986), and Goldratt (1986), for instance.

Design Matrices are set up for all the goal-strategy relations at the different levels in each branch of the goal-strategy tree. Knowledge for configuring the Design Matrices comes from the interviews, cross functional groups, existing process descriptions etc. For further evaluation of the Design Matrices and their impact on process planning see section 3.2.

This design process enables the design of a total strategy with no contradictory goals, as well as sub-strategies that affects few goals other than the ones they are intended to satisfy.

One interesting feature of using Axiomatic Design occurs when strategies affect a goal in another branch of the goal-strategy tree. See Figure 4.

If sub-strategies have an impact on goals other than those targeted, then these interrelationships can be found in the Design Matrices. An example of this could be a technology strategy that does not only affect its goal of a “need for competitive advantage through technology”, but also the Market strategy and its goal of “competitive advantage through knowledge about where and how to compete”.

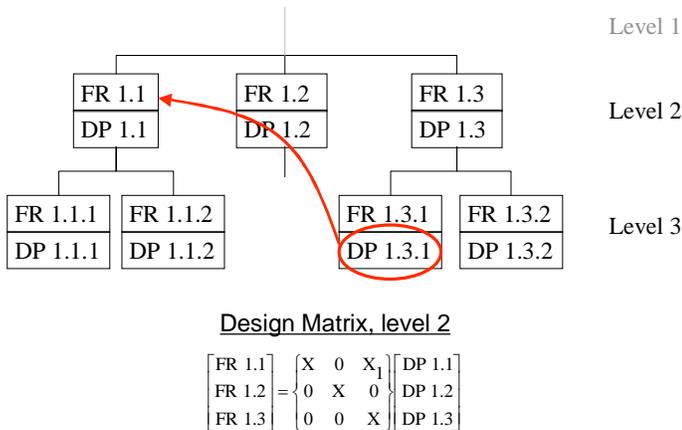


Figure 4. Design Matrix displaying cross-branch relationships in a goal-strategy tree.

In Figure 4 the cross-branch affect is displayed in the Design Matrix by using an indexed X (X_1), indicating the indirect affect of Strategy 1.3.1 on Goal 1.1. This is done at the level where the branches merge in a common Design Matrix (level 2). Indexed affects are then described in more detail (origin, reasoning, organizational impact etc.).

A design tree similar to the goal-strategy tree can also be set up for the strategy-activity relationship.

Feedback from coworkers and other stakeholders provides new knowledge and enables further trimming and redesign of the

strategic output. See Figure 3. The design support in Axiomatic Design supports this redesign. The customer input should be both internal and external to the company.

The result of the strategic design is a company-customized strategy that fulfills stakeholder needs and has goals broken down into detailed levels. For each goal there is a corresponding strategy to support that goal, and activities that support the strategies are also defined.

3.2 DESIGNING THE STRATEGIC PROCESS

It is important to carry out the sub-strategies and activities of a strategy in an optimal sequence in order to maximize the probability of success, reduce iterations, and increase implementation speed. The *process* associated with the strategy is important too.

Solving the equation systems expressed in the Design Matrices creates a process sequence that minimizes unproductive iteration and reduces rework, thereby speeding up implementation. The final result is a process chart, a flow chart, or a Gantt chart, etc., that tells how the performance of certain activities (or designing of certain sub-strategies) relates to other activities (or sub-strategies) in time. See Figure 9, Figure 10, and Figure 11.

For each sub-strategy, or activity, it is also possible to define what input is needed and where to deliver output in the strategic goal-strategy tree. See also section 4.2.2.

The optimal process sequence might be impossible to follow in reality due to company limitations, but it should provide guidance for process control efforts. It could be that the development of a certain sub-strategy, for instance a patent strategy, is dependent on input from a well-defined market strategy but that this market strategy does not exist. Then, acknowledging the inertia in large organizations, one may have to go ahead and specify the patent strategy although it is obvious that the work has to be refined when further input is delivered from the market strategy on which markets to compete in, etc.

In the case of a business strategy one might find that the technology strategy and the market strategy are fully coupled. See Figure 5. One interpretation of Axiomatic Design in the non-engineering field may be that a business strategy with such a coupling is bad and should be avoided. We think that one should be more careful when interpreting the design axioms into strategic design. A better interpretation is to accept the coupling, if no better uncoupled solution is available.

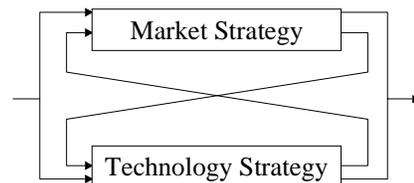


Figure 5. Coupled strategies. Information flows both ways (adapted from Eppinger et al., 1994).

Once such a coupled design is identified, it may be possible to *decouple the design by decision*. The importance of decoupling a coupled design comes from the fact that the process described in Figure 5 could theoretically iterate forever. Decoupling the design by decision means that a preferred sequence is set. If, for instance, the company described by Figure 5 wants to be market driven then the market strategy should be defined before the technology strategy. Interpreting the basics of Axiomatic Design in this way when designing non-engineering products is very similar to the game-theoretic approach of leader-followers in multidisciplinary design (Chen and Lewis, 1999).

4 INDUSTRIAL CASE STUDIES

4.1 DESIGNING A BUSINESS PLAN

This case study (Nordlund, 1996) describes an opportunity to verify the applicability of the principles and methods of Axiomatic Design are applicable in business planning. The case study was carried out in a company that had an existing business plan and was about to revise it for a new 5-year period. This gave an opportunity to compare results before and after an approach to business planning based on the design axioms (primarily the independence axiom) was employed.

The process followed in this case was as follows:

1. Use the domain framework of axiomatic design to analyze parts of the current business plan to demonstrate the potential of this approach to company management.
2. Establish a common terminology for the company business plan.
3. Teach the domain framework and the process to develop a plan to the company's executive leadership.
4. Facilitate the executives in conducting an analysis of the previous plan.
5. Develop a new plan based on the results of the analysis.

To get a commitment from the company's management to conduct their business planning based on axiomatic design, the previous plan was analyzed using the concept of domains. This analysis highlighted that there were some goals (FRs) of the company that had no strategy (DP) to meet them, some strategies (DPs) that did not seem to be directed towards any particular goal (FR). For example, note how the following statement contains both a goal (FR written in italics) and a strategy (DP, underlined): "Continuous improvement of our business is a precondition to *maintain and improve the quality level compared to our competitors.*" However there was no specific activity (PV) specified in the activity plan to realize this strategy. This may indicate that the goal will not be implemented, or that no specific plans for implementation existed. For the feasibility study a number of similar examples were investigated and presented to the company management. Based on this study, the management decided to proceed with the project and conduct a business planning activity following the framework.

In preparing the business planning activity, a common terminology was established. Words including mission, vision, goals, strategy, quality, and customer satisfaction had to be defined to ensure efficient communication.

The planning activity consisted of a half-day course on how the framework works, and some exercises applying it to prepared examples (not from their own company). Next, the previous business plan was analyzed in terms of the framework to identify current goals, activities and strategies, and also to realize what potential DPs and PVs already existed in the customer domain and the environment (the company).

Then, the executives were divided into three groups that worked in parallel. The chief executive officer, chief financial officer and the main facilitator rotated between the groups. Each group also had a group facilitator who had received thorough training in using the framework before the exercise. At the end of this activity, the groups began identifying deficiencies in the information provided by the current business plan. For example, the groups found goals without strategies and activities (FRs without DPs and PVs), as well as strategies and activities that had no goals (DPs and PVs without FRs). The groups then proceeded to generate information for these deficiencies. When all the groups had completed their work, each presented their results, and a smaller group with members from each of the three groups was formed to merge the three different plans into one.

In the time since the first business plan was developed as a part of a research project, the leadership of the company has conducted new business planning sessions following the same process, this time without the involvement of the researchers. Therefore, it is concluded that the results were not dependent upon the researchers' involvement in the process (Nordlund, 1996).

4.2 DESIGNING A TECHNOLOGY STRATEGY

This case study describes how to apply Axiomatic Design to the design of a technology strategy at a large industrial firm (Engelhardt, 1998). The *content* of the technology strategy was designed and customized for the company, as well as the *process* of the various tasks in the technology strategy. Found below is a short summary of how the work was carried out and the results achieved.

4.1.1 THE CONTENT OF THE TECHNOLOGY STRATEGY

The process followed in this case is described Table 1.

In order to create and implement an effective technology strategy, a theoretical as well as practical input was defined and synthesized. Then a goal-strategy tree was created to visualize the decomposition of high-level goals and corresponding strategies into more detailed lower-level goals and strategies.

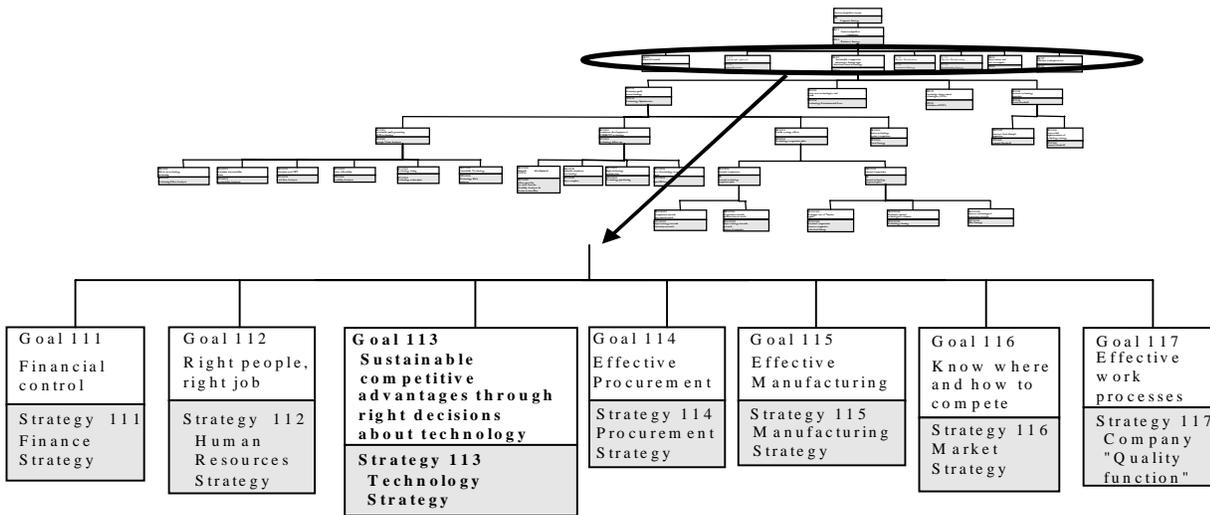


Figure 6. Functional strategies, as part of the business strategy, displayed in a goal-strategy tree.

Table 1. Steps in work process and method applied.

Step	What was done
1	Discussions with the Corporate Technology Staff at the company.
2	Review of literature
3	Initial meeting with the company's corporate board of technology to get management support for the project.
4	In-depth studies of literature
5	Qualitative, in-depth interviews with Technical Directors at the company
6	Description of goals for the technology strategy based on the steps described above and evaluation of gathered information. Use of Axiomatic Design to design strategy.
7	Goal description referred to Technical Directors for consideration.
8	Revised technology strategy. A feed back loop in the design process, see Figure 3. Consideration taken to input from step 7.
9	Second meeting with the company's corporate board of technology to officially confirm the technology strategy content and process.

The total goal-strategy tree is outlined in the upper half Figure 6.

In this case a combination of Hax' and Majluf's (1996) process framework and Ghemawat's commitment framework (1991) forms the theoretical foundation, and was found to provide a solid synthesis between the strategic content and the strategic process.

Hax' and Majluf's theoretical impact can, for instance, be found at level three in the function-means tree in Figure 6, where the corporate strategy is decomposed into functional strategies according to Hax' and Majluf's recommendations.

Ghemawat's theoretical impact is most obvious when it comes to evaluating new technologies in the Strategic Value Analysis. See Figure 7.

Several supporting strategies that were not mentioned in literature were also identified as important for the corporation. Examples of these are strategies related to successful implementation of the technology strategy, and strategies of how to effectively share technology between business units and companies within in the corporation.

For further details of the actual technology strategy that was defined, see Engelhardt (1998).

Design Matrices were set up for each level and branch in the goal-strategy tree. For example, the Design Matrix from Figure 6 is expressed in design equation (3).

While designing the technology strategy we tried to come up with solutions that were as uncoupled as possible (i.e. satisfying axiom 1). Sometimes the design matrices indicated that severe coupling existed and it was hard to find alternative solutions that suited the company. In these cases the leader-follower approach was used.

Decoupling of the design was done by giving some strategies higher priority than others. For instance the Manufacturing strategy and the Technology strategy were found to be highly coupled, and the concept of functional strategies as part of the business strategy could not be changed. See equation (3). The solution was to define the finance and market strategies as leaders, and the technology strategy as a follower. This strategic decoupling was in line with the company's will to become more market oriented.

Design decouplings, as well as other non-diagonal elements, in the Design Matrices, were indexed and explained separately. Decoupling often makes the Design Matrices lower triangular. See, for example, equation (3).

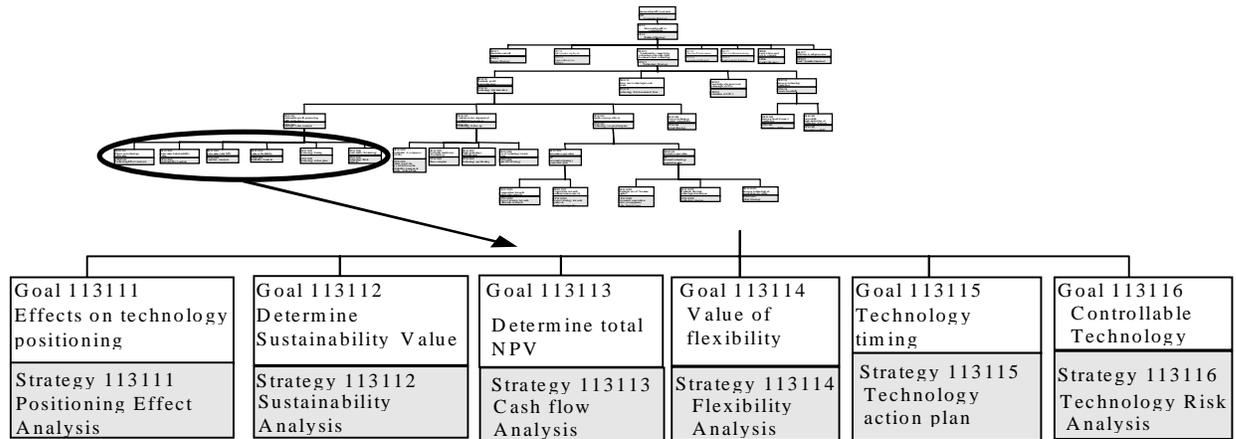


Figure 7. Parts of a Strategic Value Analysis.

Tools that could be helpful for implementing the low-level strategies in the goal-strategy tree were suggested. See Figure 8 for an example of a tool to support the strategy of Technology Risk Analysis (Strategy 113116, in the goal-strategy tree).

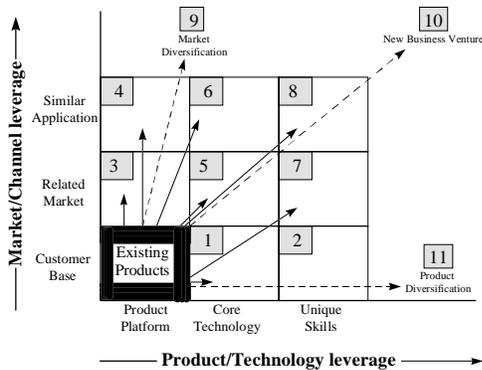


Figure 8. Suggested risk measurement tool for new technologies (adapted from McGrath, 1995).

4.2.2 THE PROCESS OF THE TECHNOLOGY STRATEGY

It is necessary to analyze how the different tasks of the technology strategy affect each other in order to plan and carry out the low-level tasks of the technology strategy as quickly and efficiently as possible. In the case of the technology strategy described above, tools and work flows etc. for the low-level strategies have to be defined in further detail.

$$\left\{ \begin{array}{l}
 \text{FR117 Effective work - process} \\
 \text{FR111 Financial Control} \\
 \text{FR116 Where \& how to} \\
 \text{compete} \\
 \text{FR113 Sustainable competitive} \\
 \text{advantages through right} \\
 \text{decisions about techn.} \\
 \text{FR115 Effective Manufacturing} \\
 \text{FR112 Right people, right job} \\
 \text{FR114 Effective procurement}
 \end{array} \right\} = \left[\begin{array}{cccccccc}
 X & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 X_1 & X & 0 & 0 & 0 & 0 & 0 & 0 \\
 X_2 & 0 & X & 0_4 & 0_1 & 0 & 0 & 0 \\
 X_3 & X_7 & X_{10} & X & 0_2 & 0 & 0 & 0 \\
 X_4 & X_8 & X_{11} & X_{14} & X & 0 & 0_3 & 0 \\
 X_5 & 0 & X_{12} & X_{17} & X_{15} & X & 0 & 0 \\
 X_6 & X_9 & X_{13} & 0 & X_{16} & 0 & X & 0
 \end{array} \right] \left\{ \begin{array}{l}
 \text{DP117 Company Quality Strategy} \\
 \text{DP111 Finance Strategy} \\
 \text{DP116 Marketing Strategy} \\
 \text{DP113 Technology Strategy} \\
 \text{DP115 Manufacturing Strategy} \\
 \text{DP112 Human Resources Strategy} \\
 \text{DP114 Procurement Strategy}
 \end{array} \right\} \quad (3)$$

The leaves at the end of the branches become, in this case, the activities for running the technology strategy process. For instance, the Patent strategy leaf (i.e. Strategy 113114 in the goal-strategy tree) has to be further developed.

In order to perform this task it is useful to know what information is needed to fulfill the task, as well as what other activities are depending on information from the fully planned Patent strategy.

For each strategy included in the overall technology strategy (i.e. all strategies in the goal-strategy tree) “input needed from” and “output delivered to” were stated. Information for this input/output clarification was stored in the design equations that express interrelationships between strategies and goals. For example, the Patent strategy has the following inputs and outputs defined: *Input needed from:* Environmental Technology Scan (which is in turn dependent on the Definition of Technology Strategic Units, Market strategy, and Finance strategy); *Output delivered to:* Technology Action Plan

Solving the equations defined by the Design Matrices enabled the setting up of process maps. See Figure 9 and Figure 10. Refer to Suh et al. (1998) for a similar flow chart description of the design of a manufacturing system.

Figure 10 shows how the Technology strategy process is dependent on high level corporate and business goals and visions (module M:1 and M:1.1). Then follows a company-specific Quality function that was intended to affect all work processes in the company, and therefore must serve as input for most activities (M:1.1.7). This Quality function has now been removed at the corporate level and work-quality responsibility has been transferred down to the various businesses of the company, thus removing strategy M:1.1.7 from the process map in Figure 10.

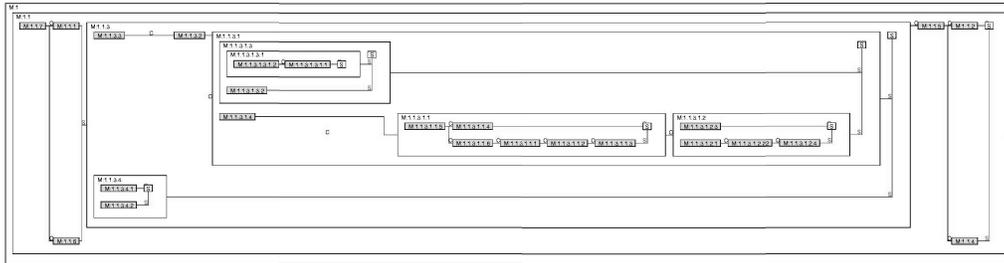


Figure 9. Schematic Overview of process for further development of sub-strategies.

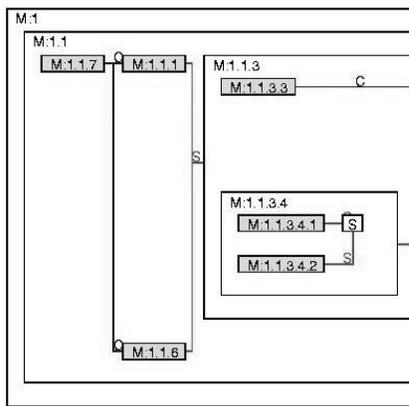


Figure 10. Close up from first part of process flowchart.

Defining the Finance strategy and the Market strategy comes early in the process (M:1.1.1 and M:1.1.6), and they serve as inputs for the subsequent activities in the process.

The process flowchart allows management to first focus on tasks that minimize rework and speed up implementation time. It also indicated certain activities that could be done immediately without having to wait for input from other activities.

The process flowchart was also expressed in terms of a Gantt chart. See Figure 11.

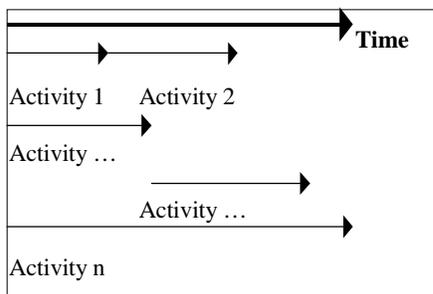


Figure 11. Hypothetical Gantt scheme for process activities.

4.1.3 RESULTS ACHIEVED FROM THE TECHNOLOGY STRATEGY CASE STUDY

A technology strategy based on the case study described above has been implemented at the company.

Fine-tuning of all the supporting strategies, or sub-strategies, is continuously performed. The process description developed helps with fulfilling this task.

Axiomatic Design proved to be a very useful tool for designing and customizing a technology strategy for the company. The approach also helped identify strategies and activities that form unnecessary couplings, and are candidates for redesign.

4 LIMITATIONS

The axioms, corollaries, and theorems in Axiomatic Design do not provide any content for the strategy. Content has to be provided by the designer. Axiomatic Design is a method that improves and clarifies the process of strategic planning.

It is important to gather correct information about the relationships that are displayed in the design equations. Information for accurate setup of the design equations and the Design Matrices comes from interviews, process descriptions, etc. How to gather this information is a very important step, but to describe this in detail is considered outside the scope of this paper.

Many other managerial and organizational tasks, in addition to the design of the strategic content and process, have to be conducted to successfully introduce and execute a strategy. These steps are also outside the scope of this thesis.

5 CONCLUSIONS

The fundamental principles and methods developed as part of axiomatic design are valid for designing non-engineering systems. In this paper it is shown that they are useful when designing a company business plan and a company technology strategy, as well as a technology strategy process plan.

A leader-follower approach based on the first and second axiom in Axiomatic Design is found valuable and useful. In terms of processes, it is important to recognize that interaction between departments is part of learning organizations, and should

Strategic Planning Based on Axiomatic Design
First International Conference on Axiomatic Design
Cambridge, MA – June 21-23, 2000

therefore not be completely designed away. However, couplings between organizational entities often yield iterative loops that reduce the probability of success and increase the time required to implement a strategy. It is important to understand and to be able to control these iterations. In the case of coupled organizations, decoupling by deciding on a preferred workflow (i.e. leader-follower approach) is necessary if an uncoupled design solution not is to find.

The use of Axiomatic Design creates a strategic process that minimizes the need for iterations. This is because Axiomatic Design forces the designer to specify the internal relationships between the different elements in the design. It also requires satisfaction of the independence axiom. Minimization of iterations saves time and money.

The renaming of functional requirements to Goals, design parameters to Strategies, and process variables to Activities increases acceptance of the Axiomatic Design framework within the business and strategic planning communities.

Overview and communication is improved when using a framework such as Axiomatic Design for developing a company specific strategy. Discussions regarding interrelations and the optimal process for implementation is also improved with the help of the design equations.

The idea of Axiomatic Design, recording goals (i.e. FRs), strategies (i.e. design parameters), activities (i.e. process variables), and their interrelationships (i.e. Design Matrices), is found valuable as a part of corporate memory.

Companies that used the Axiomatic method to strategic design have implemented the results, and have kept working with the Axiomatic Design approach to strategic planning.

6 ACKNOWLEDGEMENTS

The authors of this paper would like to acknowledge the generous support of the Engineering Design Research and Education Agenda (ENDREA), the Foundation for Strategic Research (SSF), the Royal Swedish Academy of Engineering Sciences (IVA) – Werthén fellowship, and Saab AB. Their support made this research possible.

7 REFERENCES

Akao, Y. (1991), *Hoshin Kanri, Policy Deployment for successful TQM*, editor Y. Akao, Productivity Press.

Andreasen, M. M. (1980), "Machine Design Methods based upon a Systematic Approach [In Danish]", Doctoral Thesis, *Lund University*, Lund, Sweden.

Chen, W., and Lewis, K. (1999), "Robust Design Approach for Achieving Flexibility in Multidisciplinary Design", *ALAA*, Vol. 37(8), pp. 982-989.

Deming, W. E. (1986), *Out of the Crisis*, University Press, Cambridge, MA.

Engelhardt, F. (1998), "The Content and Process of a Technology Strategy for a Large Industrial Company", Master's thesis for the Master of Business

Administration exam, *School of Business, Stockholm University*, Stockholm, Sweden.

- Eppinger, S. D., Whitney, D. E., Smith, R. P., and Gebala, D. A. (1994), "A Model-Based Method for Organizing Tasks in Product Development", *Research in Engineering Design*, Vol. 6(1), pp. 1-13.
- Erickson, T. J., and Shorey, C. E. (1992), "Business Strategy: New Thinking for the '90s", *Prism*, Fourth Quarter 1992, pp. 19-35.
- Ghemawat, P. (1991), *Commitment: the dynamic of strategy*, The Free Press, New York, New York.
- Goldratt, E. M., and Cox, J. (1986), *The Goal: A Process of Ongoing Improvement*, North River Press, N.Y.
- Hax, A. C., and Majluf, N. S. (1996), *The Strategy Concept and Process: A pragmatic Approach*, Prentice-Hall, Upper Saddle River, New Jersey.
- Kerin, R. A., Mahajan, V., and Varadarajan, P. R. (1990), *Contemporary Perspectives on Strategic Planning*, Allyn & Bacon, Boston.
- Kotler, P. (1997), *Marketing Management: Analysis, Planning, Implementation, and Control*, Ninth Edition, Prentice-Hall, Upper Saddle River, New Jersey.
- Marples, D. L. (1961), "The Decisions of Engineering Design", *IRE Transactions on Engineering management*, EM-8(2), pp. 55-71.
- McGrath, M. (1995), *Product Strategy for High-Technology Companies*, Irwin Professional Publishing, Burr Ridge, Ill.
- McGrath, M. E. e. (1996), *Setting the PACE in Product Development: A guide to product and cycle-time excellence, Revised Edition*, Revised edition, editor M. E. McGrath, Butterworth-Heinemann, Newton, USA.
- Nordlund, M. (1996), "An information Framework for Engineering Design based on Axiomatic Design", Doctoral Thesis, *dep. of Manufacturing Systems, Royal Institute of Technology*, Stockholm, Sweden.
- Peters, T. J., and Waterman Jr., R. H. (1982), *In Search of Excellence: Lessons from America's Best-Run Companies*, Harper & Row, New York.
- Porter, M. (1980), *Competitive Strategy, Techniques for Analyzing Industries and Competitors*, The Free Press, New York.
- Porter, M. E. (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press, New York.
- Prahalad, C. K., and Hamel, G. (1990), "The Core Competence of the Corporation", *Harvard Business Review*, Cambridge, MA, USA, May-June 1990, pp. 79-91.
- Robbins, S. P. (1994), *Essentials of Organizational Behavior*, Prentice-Hall, Englewood Cliffs, New Jersey.
- Senge, P. M. (1990), *The fifth Discipline: the art and practice of the learning organization*, Doubleday/Currency, New York.
- Suh, N. P. (1990), *The Principles of Design*, Oxford University Press, New York, NY.
- Suh, N. P., Cochran, D. S., and Lima, P. C. (1998), "Manufacturing System Design", *Annals of CIRP*, Vol. 47(2).