

Management of R&D-Based Corporate Venturing

by

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ABSTRACT

This thesis studies the management of the technology-based corporate venturing process. Creating new businesses within existing organizations is of primary significance today. New businesses start up one after another in the U.S. and they affect and change society dynamically. In many, R&D forms the basis of their business and plays a key role. In contrast, Japanese industries are less flexible and dynamic with new business creation. Based on this awareness, NTT's (Nippon Telegraph and Telephone Corporation's) case was analyzed to elucidate the management problems first. Then, both secondary literature study and interviews with fourteen people in three U.S. firms were used to scrutinize favorable management practices and strategy procession for technology-based new business development.

Based on the comparative analysis of this information and NTT's management, a consistent process model of technology-based new businesses development was elaborated. Throughout the development process, the study found the importance of interfunctional linkages between the technology side and marketing side. Four modes of interfunctional linkage were described:

- 1) information exchange,
- 2) collaboration within a multidisciplinary teams,
- 3) personnel linkages, and
- 4) intermediation by experts or special organizations.

Effective linkage methods differ with stage of the development process, and appropriate employment of these methods to each process stage was examined. As part of achieving these linkages, several institutional factors were also examined.

Thesis Supervisor: Edward B. Roberts

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CHAPTER 1

INTRODUCTION

The principal purpose of this thesis is to clarify R&D management problems encountered in creating technology-based new businesses. Creating new businesses and generating innovation within existing organizations is of primary significance for large enterprises today. The direct objective of such innovation is to widen the business field and to improve the organization's performance. Another significance is to produce and keep entrepreneurship among the organizations' employees. One of the greatest advantages inherent in U.S. industry as compared with Japanese industry is its flexibility and dynamism in corporate venturing. New businesses start up one after another in the U.S. and they affect and change the society dynamically. New entrants replace the existing enterprises, and whole industries keep growing. In many of them, R&D forms the basis of their businesses and plays a key role in creating new industry. This new industry absorbs part of the workforce of the old industries and creates the dynamics for change in the industrial structure. This dynamism is going to be highly significant in emerging multimedia business opportunities.

In contrast, Japanese industries have been doing R&D based on a conventional philosophy that still emphasizes market share and cost competitiveness.¹ This worked well until the mid-1980s. For example, Japanese industry was very strong in the mass production of "stand-alone products" like VCR and DRAM, which have competitive advantages in cost and quality. Japanese R&D has improved and expanded existing technology to create higher performance products in the same market. However, the world electronics market points to

¹ Finan, W.F. and Frey, J., "Japan's Crisis in Electronics: Failure of the Vision," *Nihon Keizai Shinbun-Sya*, April 1994, pp.23-138.

system products in which software makes the added value. There was discontinuous technological change like analog to digital and central processing to dispersed processing in this field, and Japanese electronics industries got a late start in remaining current with this discontinuous change. This is clearly shown in the case of analog HDTV, with which some industrial firms still remain. As a result, Japanese industries are concerned about their reduced vitality coupled with the serious economic difficulties.

One such example can be drawn from the case of NTT (Nippon Telegraph and Telephone Corp.). Seventy percent of NTT's annual revenue still comes from conventional telephone charges.² This has now become a mature source of revenue. Therefore, since 1985, many trials of technology-based new business development were attempted to develop a second source of income. However, almost all of them failed, mainly because of managerial problems rather than technological problems. As a result of these experiences, NTT is struggling for better management and improved systems, especially in R&D.

Based on an analysis of both secondary literature and a field study, I will scrutinize and discuss the art of R&D management as it enables and promotes flexibility and dynamism in new business development. In prior studies, a technology innovation process, a product development process, and a business development process have been investigated individually.^{3,4,5} However, in the case of R&D-based corporate venturing, these processes must have an intricate relationship with each other. The right timing throughout the process is particularly important in order to facilitate market access. This thesis will also identify a consistent

² NTT Advertising Department, *NTT Data Book '93*, Nov. 1993, p.146.

³ Roberts, E.B. "Managing invention and innovation," *Research Technology Management*, Jan.-Feb. 1988, pp.11-29.

⁴ Takeuchi, H and Nonaka, I., "The new new product development game," *Harvard Business Review*, Jan.-Feb. 1986, pp.137-146.

⁵ Block, Z. and MacMillan, I.C., *Corporate Venturing*, Cambridge, MA: Harvard Business School Press, 1993, pp.11, 177.

process model and its management of R&D-based new business development.

In Chapter 2, literature regarding former studies that are relevant to the topic of technology-based new business development is reviewed to examine the effective management of the development process.

In Chapter 3, my research framework and methodology are described.

Chapter 4 reviews NTT's trial of technology-based new business development. There were six business development projects and three of them failed. Management problems are scrutinized through the detailed review of one failed example.

Chapter 5 describes three examples of U.S. firms' R&D management and related business development trials. This information is compared with NTT's management to develop a better R&D management system in Chapter 6.

In Chapter 6, a new process model of R&D-based business development is elaborated. The process model focuses on the interfunctional linkage of R&D and marketing.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews literature relevant to the topic of technology-based new business development. Specifically, this chapter will focus on studies relating to the flow of human resources, money, and information between technology and the market, along with a close scrutiny of a consistent development process. In addition, this chapter will also review some important studies on technology strategies and business strategies which have a close relationship with the development process and its management.

This chapter is divided into three sections:

- Technology, Product and Business Development Process.
Many studies have been done concerning the technology development process, the product development process and the business development process individually. In the case of technology-based corporate venturing, it is hypothesized that these processes have an intricate relationship with each other. Therefore, studies concerning each process are examined from this point of view.
- Interfunctional Linkage of R&D and Marketing.
Interaction between R&D and marketing for better development is a popular and historic subject. A number of studies have been done, but many of them focused on the communication between R&D and marketing in the early development stage to reflect market needs to the R&D process.^{6,7} However, this interaction is necessary throughout the whole process, and how the proper linkage

⁶ Hauser, J., "Consumer Research to Focus R&D Projects," *Journal of Product Innovation Management*, vol. 2, 1984, pp.70-84.

⁷ Bonnet, D.C.L., "Nature of the R&D/Marketing co-operation in the design of technologically advanced new industrial products," *R&D Management*, vol.16, 2, 1986, pp.117-126.

at the proper time is realized is a substantial subject.⁸ Prior to the discussion of field study results, earlier studies are examined.

- Venturing Strategy. In the case of successful corporate venturing, selection of the right strategy corresponding to the market and the competitive situation is the substantial effort of management. For the case study of NTT and the other companies, a clear framework of the strategy analysis is necessary, too. Two well organized studies on the technology strategies and entry strategies are examined.

2.1 Technology, Product and Business Development Process

2.1.1 Technology Innovation Process

A correct understanding of the innovation process is the basis of better management. Roberts has shown a precise analysis of the technological innovation process.⁹

Innovation is composed of two parts: (1) the generation of ideas or inventions, and (2) the conversion of that invention into a business or other useful application. This is expressed as a simple definition of:

Innovation = Invention + Exploitation.

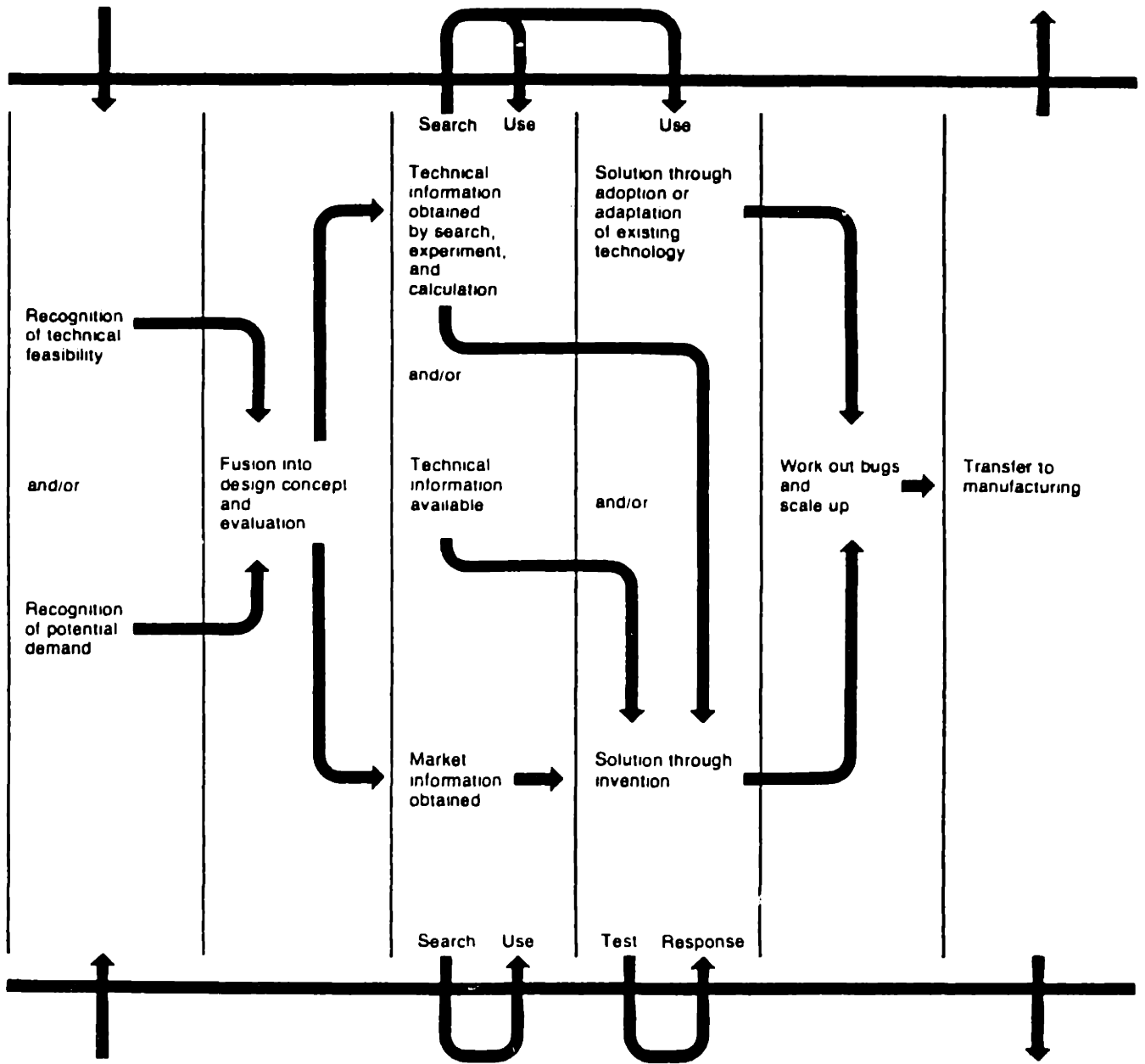
Jack Goldman, former head of research at Xerox, also said that "innovation" is the transformation of an invention into a business.¹⁰ The common wisdom about these two concepts is that innovation is more than "Research and Development," and covers the whole process from technology to business. A more precise breakdown is shown in Figure 1. In this figure, "Invention" is shown as the stages from 1 to 4, and "Exploitation" is indicated as stages 5 and 6, respectively.

⁸ Gupta, A.K., Raj, S.P., and Wilemon, D., "The R&D-Marketing Interface in High-Technology Firms," *Journal of Product Innovation Management*, vol.2, 1985, pp.12-24.

⁹ Roberts, E.B., "Managing Invention and Innovation," *Research Technology Management*, Jan-Feb 1988, pp.11-29.

¹⁰ Smith, D.K. and Alexander, R.C., *Fumbling The Future*, New York:Quill, 1988.

Technology



Market

1	2	3	4	5	6
Recognition of opportunity	Idea formulation	Problem solving	Prototype solution	Commercial development	Technology utilization and/or diffusion

Figure 1. Technological innovation process (Roberts, 1988, p.12)

From this diagram, we can learn the flow and connection of different tasks. It also shows that there is an important linkage between technology and market in almost every stage. Therefore, a system or methodology that realizes these connections and linkages becomes the management subject.

In general, successful management of technological innovation depends on using human and capital resources effectively at each stage. In addition to the differences in the primary task at each stage, managerial issues show significant variation among these stages. For example, the managerial questions at Stage 1 are, "How do we generate more and better targets? Which people, organizations, and strategies should be employed for these objectives?" Therefore, good management practice at Stage 1 tends to involve "loose control." On the other hand, managerial issues in the latter stage involve coordinating people toward achieving pre-defined successful outcomes within budget and on schedule. Effective practices involve tight control of schedules and elimination of duplication. These practices are the opposite of what is encountered in the early stage. Therefore, different management is required for each stage. Managing capital resources corresponding to each stage is relatively easy, however, staffing considerations are much more difficult. Therefore, reexamination of the personnel system is also needed to assign the right person to the right phase, depending on the situation.

Figure 1 also demonstrates the interaction between technology and the market in each phase. In each stage of technological innovation, proper interaction with the market is necessary. Input of market information into design during the early stages of technological innovation is especially crucial. However, establishing and maintaining this interaction is the real problem. There usually is a deep gap between the market and technology. Roberts has pointed out that the human bridge is the best and only way to realize

effective technology transfer from R&D to manufacturing.¹¹ Similar claims can be made about the communication between R&D and the market. Even though it was an exception, Roberts showed the existence of an R&D organization that had marketing people inside.¹² Therefore, personnel decisions should be examined to facilitate this communication.

Brian Twiss, a consultant of the International Management Center in London, showed another perspective of the technological innovation process.¹³ He examined technological innovation as a conversion process, as shown in Figure 2. Figure 2(a) is a product-oriented approach and 2(b) is a market-oriented approach. Both diagrams clearly show the importance of interaction between sources of input, knowledge, information, and materials. However, Twiss did not show how to realize the interaction in the conversion. Therefore, the system or methodology must be further clarified.

2.1.2 Product Development Process

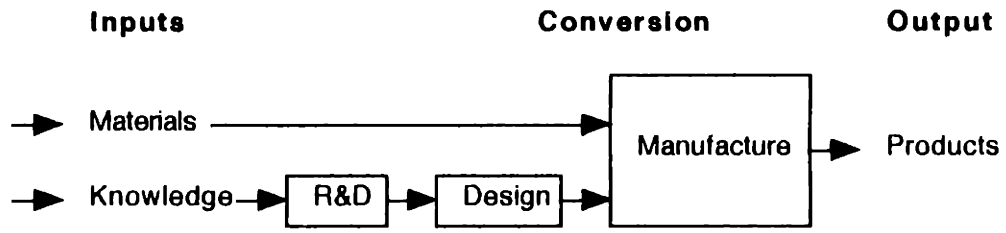
Takeuchi and Nonaka analyzed product development processes to meet the competitive requirement.¹⁴ They divided the product development process into six phases: concept development, feasibility testing, product design, development process, pilot production, and final production. The "concept of product" must reflect the results of the prototype solution in the "technology innovation process." Consequently, the relationship between the technology innovation process and the product development process can be diagrammed as in Figure 3.

¹¹ Roberts, E.B., "Technology Transfer from Research to Engineering to Manufacturing," *class note*, Nov. 9 1994.

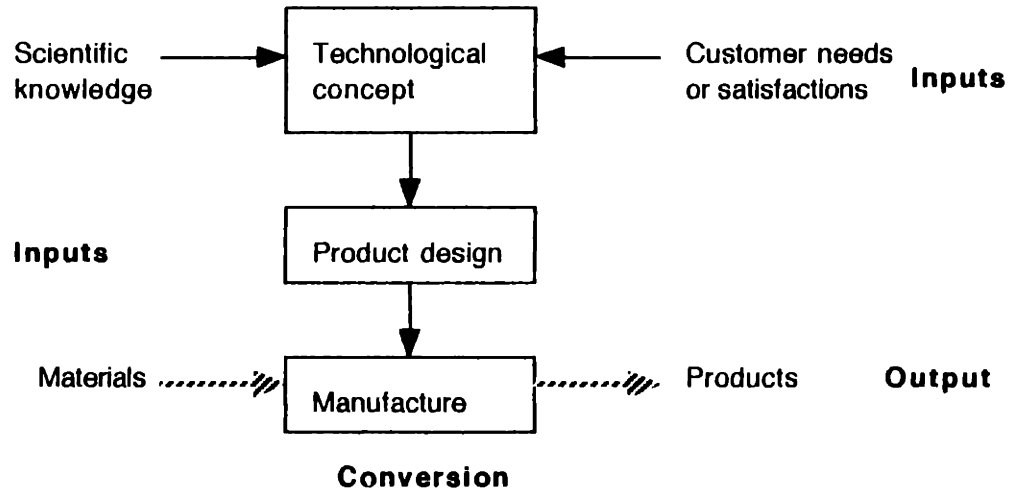
¹² Roberts, E.B., "Stimulating Technological Innovation - Organizational Approaches," *Research Management*, Nov. 1979, pp.26-30.

¹³ Twiss, B., *Managing Technological Innovation*, London and New York: Longman, 1986, pp.3-24.

¹⁴ Takeuchi, H and Nonaka, I., "The new new product development game," *Harvard Business Review*, Jan.-Feb. 1986, pp.137-146.



(a) Conversion Process 1



(b) Conversion Process 2

Figure 2 Technological innovation as a conversion process
(Twiss, 1986, p.4)

Technology Innovation

Product Development

Old

New

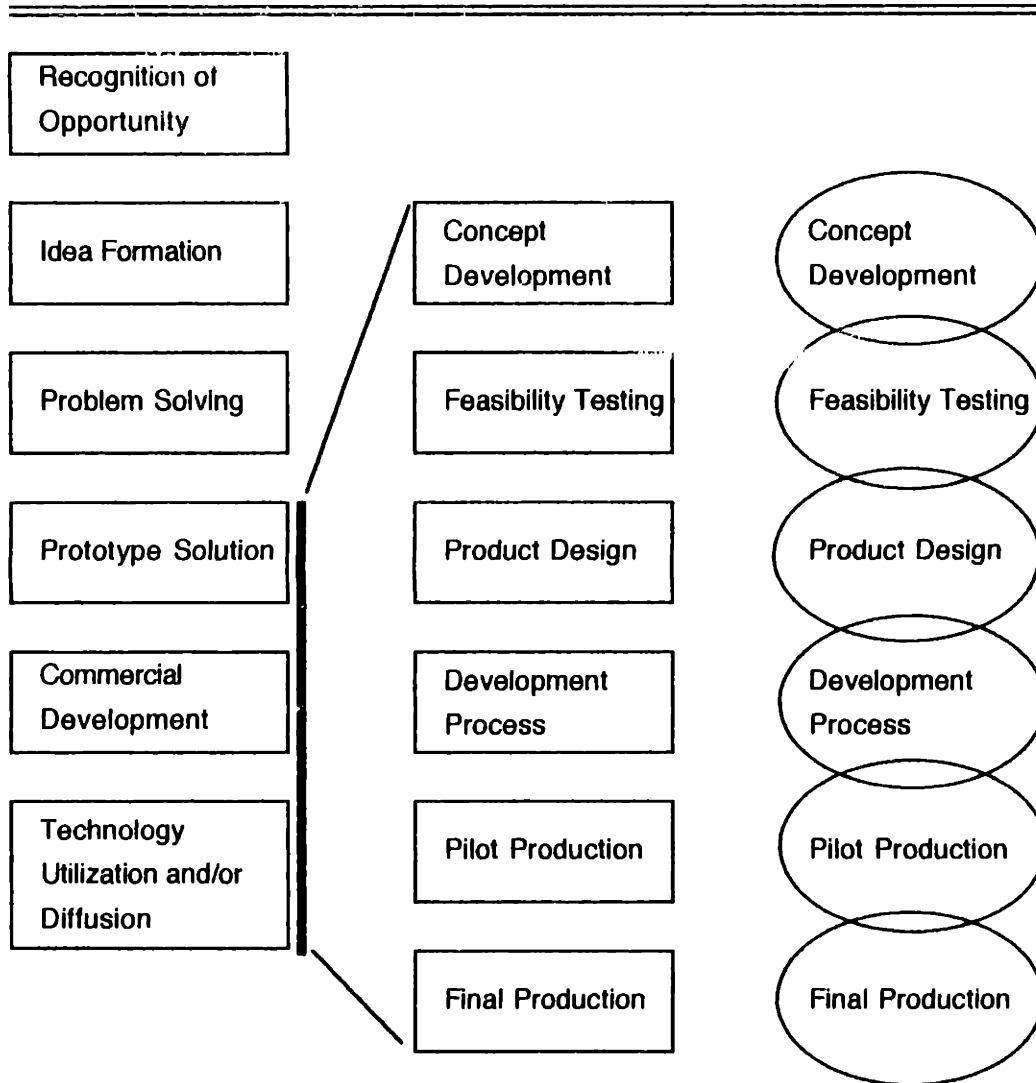


Figure 3 Technology innovation process and product development process

(Takeuchi and Nonaka, 1986, pp.137,139)

In traditional forms of development, the product development process went sequentially from phase to phase and the specialized functions in each phase were carried out by functional specialists: marketing people examined customer needs; the R&D engineers selected the appropriate design; and production engineers put it into shape. However, according to Takeuchi and Nonaka's analysis, to realize the speedy and flexible new product development, an overlap approach should be taken instead of the sequential approach. This approach is also diagrammed in Figure 3. In this approach, the process emerges from the constant interaction of a multidisciplinary team whose members work together from start to finish. This interaction enables the group to integrate the power and to absorb the "noise" originated in the problem. This overlapping process appears to be a successful solution to the difficulty of establishing the interaction between the market and technology. As mentioned earlier, Roberts pointed out that the most effective bridge between R&D and marketing is realized by people's movement in both directions. Therefore, creating a multidisciplinary team by personnel transfer will be an effective way to achieve successful product development. My field study examined this effectiveness in some real examples.

Another important aspect of this interaction is the range of "market." Goodman and Lawless discuss an effective match between the firm's competencies and the environment.¹⁵ He believes that competency and the environment can be considered as an expanded domain of technology and the market. Considering the environment rather than the simple market is very valuable for product development, because consideration of the competitive situation is quite important for product development strategy. This again brings up the bridge between technology, the market, and/or the environment, that is, a bridge by a higher-level person may

¹⁵ Goodman, R.A. and Lawless, M.W., *Technology and Strategy - Conceptual Models and Diagnostics*, New York: Oxford University Press, 1994, pp.56-67.

be more effective. Moreover, mutual transfer from each side to the other will be effective for a strategic analysis of the competitive situation and its feedback. Such issues are discussed in detail in Chapter 6.

2.1.3 Business Development Process

Similar to the technology innovation process and the product development process, the venturing process was also analyzed by Block and Macmillan¹⁶. They conceived a six-stage model to describe the management roles of the parent sponsoring organization and venture management (see Table 1). The model depicts "Setting the Stage," "Choosing Ventures," "Planning, Organizing, and Starting the Venture," "Monitoring and Controlling the Venture," "Championing the Venture," and "Learning from Experience." Two types of management roles at each stage are summarized in Table 1. However, it is necessary to understand the basic difference between these two types of management. In the case of parent organization management, basic framework involves making good use of corporate resources to keep business as usual. For example, decisions for venturing tend to become conservative. On the other hand, this clearly obstructs the venture opportunities. Therefore, realizing a good relationship and interaction between parent organization management and venture management becomes significant. NTT has experienced many problems in the early start-up stage in their venture projects, and these problems tend to originate from management conflict between these two types of management.

To analyze these problems, this macro process model is not enough and a more precise process analysis is necessary. One example is shown in Figure 4. This process focuses especially on the venture activity, so we need to integrate the parent organization's activity in order to get a better

¹⁶ Block, Z. and MacMillan, I.C., *Corporate Venturing*, Cambridge MA: Harvard Business Press, 1993, p.10.

Table 1. Venturing process model

Setting the Stage	
<p>Senior management decides whether venturing is strategically desirable and necessary for the organization, creates conditions that will encourage a flow of venture ideas, and designs and frames the process for managing the venturing activity.</p>	
Choosing Ventures	
<p>Senior management selects venture management and may also establish the compensation basis at this point.</p>	<p>Venture champions identify, evaluate, and select opportunities and build venture proposals for presentation to senior management.</p>
Planning, Organization, and Starting the Venture	
<p>Senior management determines where each venture should be located within the organization and how it should interface with other units.</p>	<p>Venture management completes the development of a business plan for the approval of senior management and, upon approval of the plan, organizes and launches the venture.</p>
Monitoring and Controlling the Venture	
<p>Senior management monitors and controls corporate risk level.</p>	<p>Venture management manages and controls the venture.</p>
Championing the Venture	
	<p>Venture management, while continuing to champion the venture, must hone its survival skills and learn how to manage the inevitable challenges of corporate politics.</p>
Learning from Experience	
<p>Senior management uses systematic methods of information gathering and analysis to learn how to manage the initial venturing process more effectively.</p>	<p>Venture management uses systematic methods of information gathering and analysis to learn how to manage ventures more effectively.</p>

Source: Block and MacMillan 1993, p.11

Business Development

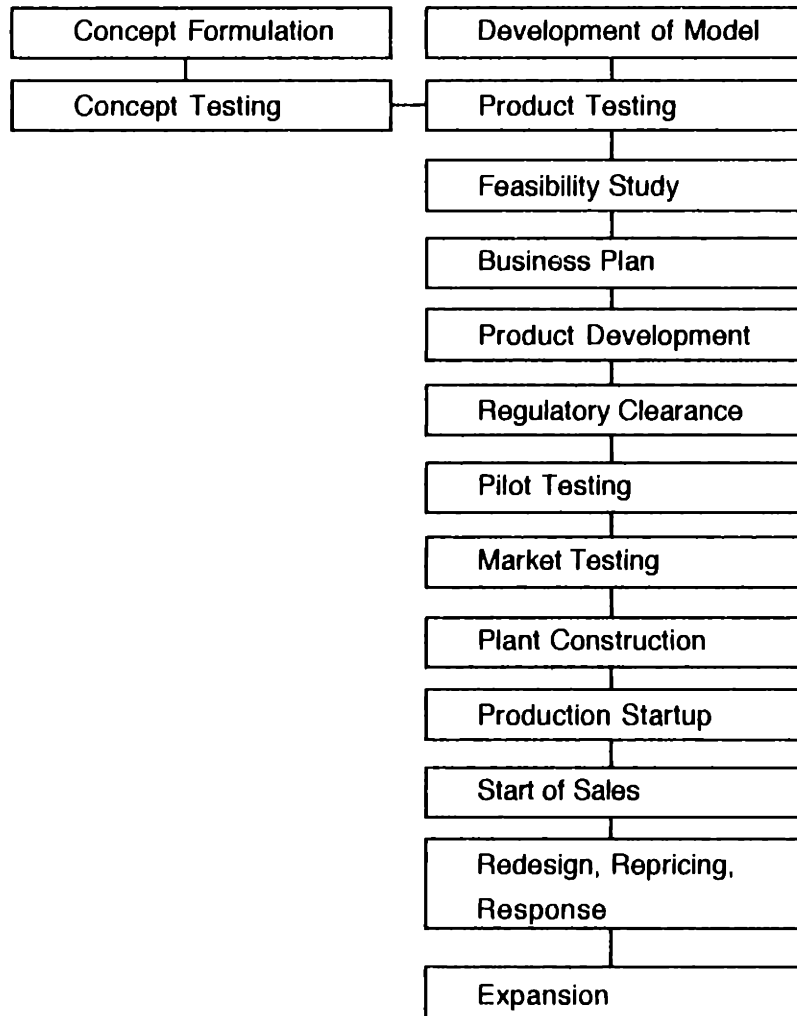


Figure 4 Business development process

(Block and MacMillan, 1993, p.177)

understanding of whole process. In Figure 4, business concept formulation is closely related with product concept development shown in Figure 3. Also, a great deal of feedback from the latter stage in Figure 4 to the former stage of Figure 3 must be considered. These two processes has been studied independently, but both have a close and intricate relationship with each other. Therefore, examining the consistency of Figure 3 and 4 is quite meaningful for technology-based venturing.

2.2 Interfunctional Linkage of R&D and Marketing

For successful innovation, the proper linkage between R&D and marketing at the proper timing is one of the most important functions throughout the process. This is a popular and historic subject and a number of studies have been done. However, many of them focused on the communication between R&D and marketing in the early development stage to reflect the market needs to R&D process. Moreover, the practice of linkage seems to occur infrequently, in spite of the large number of relevant studies.

Hauser showed one case study in which market research methodology was applied to the analysis of a new product concept.¹⁷ Using the example of "Video Telephone," consumers' perceptions were analyzed qualitatively. The analyzed preferences can be reflected to the new product design. This methodology is effective in finding a right direction in the early R&D stage. However, the measurement depends strongly on the concept description. Therefore, the translation of technological characteristics to the common language must be done carefully.

¹⁷ Hauser, J., "Consumer Research to Focus R&D Projects," *Journal of Product Innovation Management*, vol 2, 1984, pp.70-84.

Bonnet has studied an actual example of R&D/Marketing cooperation in ten U.K. firms.¹⁸ According to his survey, very few firms have effectively implemented the integration of R&D and the marketing functions, although they have praised its benefit. In over 70% of cases the involvement of marketing was simply to provide estimates of market potential of the new product idea. Bonnet concluded that the linkage between R&D and marketing is especially important for product design, and he showed major components of the linkage as illustrated in Figure 5. Components of both sides' effort are clearly explained, but how we can realize these linkages in real development activity is still vague. Methods such as a human bridge or some institutional factor should be discussed for the implementation. Moreover, the linkage in the other stage of new product development should also be examined.

Souder showed a very good correlation between R&D/marketing linkage problems and project success/failure through the results of in-depth interviews.¹⁹ In the case of projects that had severe interface problems, the success rate became very low. On the other hand, 66.7% of successful projects had no significant interface problems. Interface problems are divided into four types; (1) lack of communications; (2) lack of appreciation; (3) distrust; (4) too-good friends(lack of objectivity). As a result of his case studies, the following ten guidelines were suggested for overcoming these problems:

1. Break large projects into smaller ones,
2. Take a proactive stance toward interface problems,
3. Eliminate mild problems before they grow into severe problems,

¹⁸ Bonnet, D.C.L., "Nature of the R&D/Marketing cooperation in the design of technologically advanced new industrial products," *R&D Management*, vol.16 Feb. 1986, p.117-126.

¹⁹ Souder, W.E., "Promoting an Effective R&D/Marketing Interface," *Research Management*, July 1980, pp.10-15.

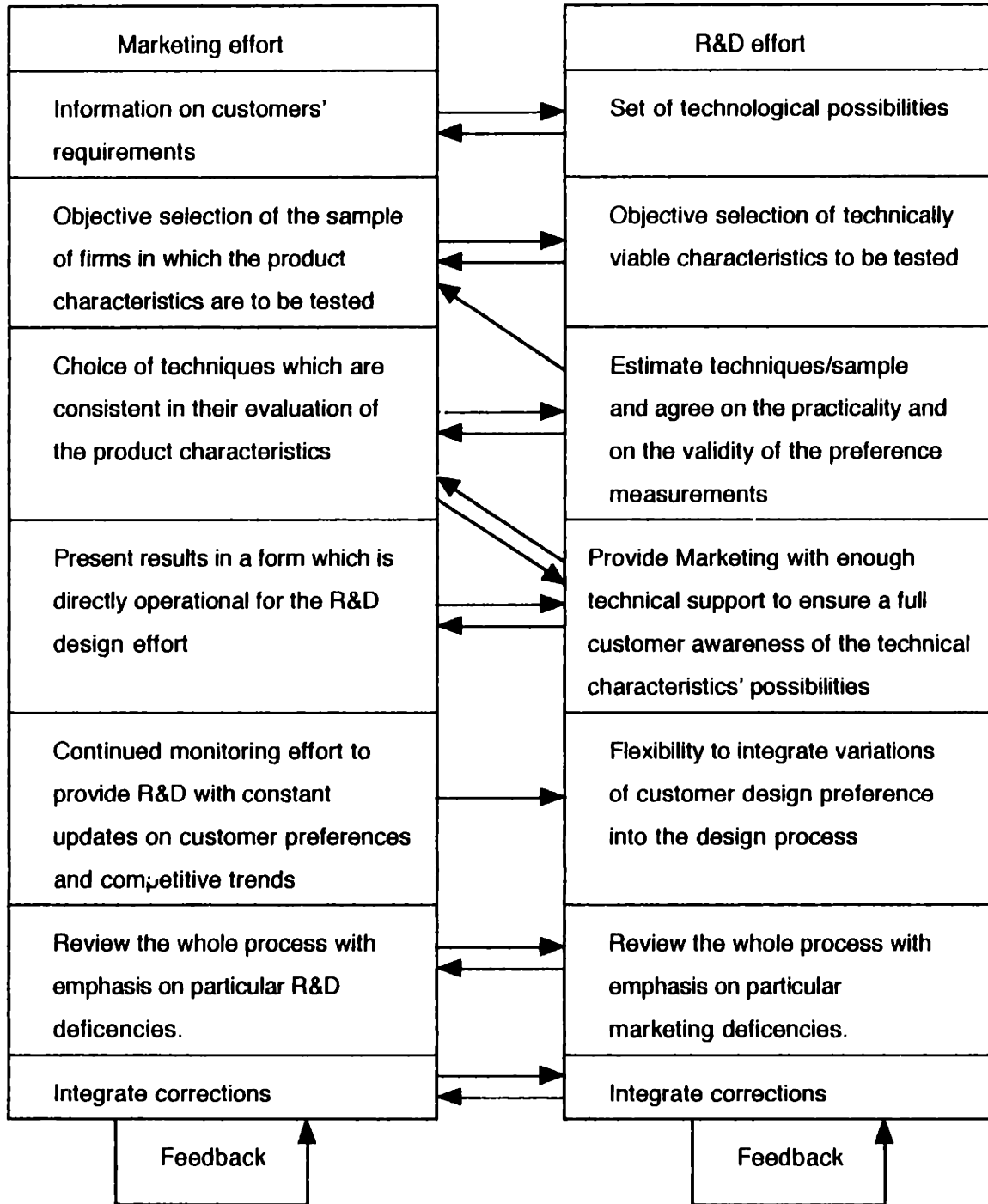


Figure 5. Components of the R&D/Marketing design link
 (Bonnet, 1986, p.124)

4. Make open communication an explicit responsibility of everyone,
5. Promote dyadic relationships between R&D and marketing,
6. Create a New Products Committee to steer and guide the efforts,
7. Appoint only highly qualified individuals as project managers,
8. Involve both parties, early in the process,
9. Try to obtain agreement on the decision authority in each meeting between R&D and marketing, and
10. Set up a new product development organization structure that is appropriate for the nature of the technology and the market.

All of these are still guidelines, but effective for thinking about a better linkage system.

In contrast to the above-mentioned studies, Gupta, Raj, and Wilemon showed that R&D and marketing integration is required in all phases of product innovation.²⁰ There are three phases that require the integration:

- during the planning phase,
- during the new product development phase, and
- after the commercialization phase.

In these phases, integration can help the following activities:

- Establishing priorities and goals,
- Establishing schedules,
- Preparing a budget,
- Idea screening/business analysis,
- Development, and
- Testing and commercialization.

For example, jointly developing budgets can help both R&D and marketing know when funds for a particular project need to be cut or increased. If a strategic decision to double

²⁰ Gupta, A.K., Raj, S.P., and Wilemon, D., "The R&D-Marketing Interface in High-Technology Firms," *Journal of Product Innovation Management*, vol.2, 1985, pp.12-24.

expenditures for a specific product is required to retain a competitive edge, integration helps the decision-making process greatly. This perspective is quite similar to my basic approach in this study, and their analysis will be examined again along with constructing a total process model in Chapter 6.

2.3 Venturing Strategy

2.3.1 Technology Strategies

Besides a clear philosophy and explicitly stated reasons for venturing, a clear strategy is also necessary for successful technology development and product development. Goodman and Lawless have examined nine technology strategies.²¹ Sometimes technology people tend to focus only on price competitiveness, performance, and lead time. However, more diversified strategies are also available. Some of them appear to be overlapping, but yield a fairly wide perspective.

a) Technological commodity search

This strategy focuses on the trailing edge of the product life cycle. In this stage, the products are standardized and well understood, and there are very few new entrants. Successful firms in this arena invest in cost-reducing manufacturing processes and maintain low prices.

b) Preemption

This strategy pursues a cost advantage similar to a). The difference between a) and b) is the investment for a large-capacity plant as a first mover. If the plant capacity is large enough to cover the entire market and to realize low cost, investment in this market by competitors will be

²¹ Goodman, R.A. and Lawless, M.W., *Technology and Strategy - Conceptual Models and Diagnostics*, New York: Oxford University Press, 1994, pp.56-67.

meaningless for gaining market penetration. Focus on a niche market is more sensible at this phase.

c) Productive efficiency

This is also a low-cost approach. However, in contrast to the former niche market case and the tail-end life cycle market, this strategy focuses on the large mass market within a highly competitive situation. The technological strategy is to invest in the manufacturing process to gain productive efficiency.

d) Producer preference

This strategy is adopted in the early stages of a new technologically complex product. When the new product has a functional value significantly in excess of substitute products, and the firm's ability to supply the market is limited, the firm is in control of the market. This is sometimes referred as first mover advantage, and the investment focuses on research.

e) Production flexibility

This approach can create an opportunity to move quickly from design to production. This speed enables the firm to get its products to market before the competition can emerge. If the market is small, this ability is preemptive in nature. A typical example of flexible manufacturing is the application of CAD/CAM.

f) Customer preference

The essence of this strategy is to tailor the product to the special needs of groups of customers. This customization is realized by the flexibility of design and production, but this flexibility must be limited for lowcost.

g)Product pioneer, product leader, product follower

In the computer industry, Apple was the product pioneer, IBM is a product leader, and the others are product followers. The pioneer can achieve a significant payoff, but also has a risky investment. Actions should be considered depending on the market phase. If the market is in the initial phase, investment must be focused on development. In a growing market, heavy investment focused on the product and market development is necessary. In a mature market, investment should be concentrated on special-purpose designs for a niche market.

h)Vertical integration

This strategy realizes better utilization of available technological resources. In the case of Japanese car manufacturers, they realize a good supplier-buyer relationship with components manufacturers. They cooperate with each other from the design stage. However, the supplier-buyer relationship is not always stable in general, especially in the case of large complex products. Therefore, the establishment of the balanced relationship between these two is strategically important. Both forward and backward integration are possible.

i)Complementary technology

The complementary technology strategy reduces both entrance barriers and potential customer's switching cost, as in the IBM-compatible computer. In general, the market size for them is smaller than that of the mainline producer. Therefore, direct competition with a mainline producer is necessary.

In the case of high-tech based venturing, the preemptive entrance, product preference, and/or product pioneer strategies tend to be considered, as I will explain in NTT's case. This is because of their technological background and

experience. However, the strategy also depends on market size and competitive situation. If the market will be very large, productive efficiency must be considered as one of the desirable strategies. Therefore, a precise analysis on both technology and market is necessary to have exact strategies. These nine strategies have some redundancy, but are well considered from three viewpoints; market/product situation, defensibility, and return.

2.3.2 Entry Strategies

In the case of new business development, "development" addresses a new market and new technology. A correct understanding of this new market and technology strongly affects the strategies. Roberts and Berry examined entry strategies from the viewpoint of this newness in the market and technology.²² The basic concern of this study is that successful development may not come until familiarity with both market and technology are achieved. Market familiarity was measured based on the questions shown in Table 2, and

Table 2. Tests of market familiarity

-
1. Do the main features of the new market relate to or overlap existing product markets?
 2. Does the company presently participate in the market as a buyer?
 3. Has the market been monitored systematically from within the corporation with a view to future entry?
 4. Does knowledge of the market exist within the corporation without direct participation in the market?
 5. Is relevant and reliable advice available from external consultants?
-

²² Roberts, E.B. and Berry, C.A., "Entering New Businesses: Selecting Strategies for Success," *Sloan Management Review*, Vol. 26, No. 3, 1985, pp. 3-18

technology familiarity by the questions in Table 3. From this examination, we can judge better entry strategies. As a whole, firms should take a less involved mechanism like venture capital, when they are unfamiliar with the technologies and the markets. In contrast, they can do internal development when they have enough familiarity with the market and the technology. This relationship is summarized in Figure 6. Based on this discussion, we can select the optimum entry strategies for new business opportunities. Propriety of NTT's strategy in former experiences is examined using these frameworks in Chapter 4.

Table 3. Tests of technological familiarity

-
1. Is the technological capability used within the corporation without being embodied in products?
 2. Do the main features of the new technology relate to or overlap with existing corporate technological skills or knowledge?
 3. Do technological skills or knowledge exist within the corporation without being embodied in products or processes?
 4. Has the technology been systematically monitored from within the corporation in anticipation of future utilization?
 5. Is relevant and reliable advice available from external consultants?
-

Market Factors	New Unfamiliar	Joint Ventures	Venture Capital or Venture Nurturing or Educational Acquisitions	Venture Capital or Venture Nurturing or Educational Acquisitions
	New Familiar	Internal Market Developments or Acquisitions	Internal Ventures or Acquisitions or Licensing	Venture Capital or Venture Nurturing or Educational Acquisitions
	Base	Internal Base Developments	Internal Product Developments or Acquisitions or Licensing	"New Style" Joint Venture
		Base	New Familiar	New Unfamiliar
		Technologies or Services Embodied In the Product		

Figure 6 Optimum entry strategies

(Roberts and Berry, 1985, p.13)

CHAPTER 3

Research Design and Methods

3.1 Framework

The major objective of this research is to develop a consistent process model of technology-based new business development. The model is constructed based on three independent process models: technology development process, product development process, and business development process. Throughout this process, I focus on achieving more effective interfunctional linkage between the technology side and the market side.

Many studies have been done about R&D/Marketing cooperation, but the discussion has focused mainly on communication and the reflection of market needs to R&D.^{23,24,25}

The main subject of management is resource allocation along with the strategy, where resources imply human resources, money, and information. Therefore, the interaction between the technology side and market side should be considered not only from the viewpoint of communication, but from the organizational viewpoint, that is, a human bridge and financial relations. The flow of these resources (human, money, and information) center around the project, and many varieties of flows can be considered as one-way, two-way, via an intermediary, formal, informal, etc. From the review of NTT's trial of new business development and the study of the other U.S. firms' examples through my interviews, a desirable

²³ Hauser, J., "Consumer Research to Focus R&D Projects," *Journal of Product Innovation Management*, 1984; 2, p.70.

²⁴ Bonnet, D.L.C., "Nature of the R&D/Marketing co-operation in the design of technologically advanced new industrial products," *R&D Management*, vol.16, 2, 1986, p.117.

²⁵ Gupta, A.K., Raj, S.P., and Wilemon, D., "R&D and Marketing Dialogue in High-Tech Firms," *Industrial Marketing Management*, vol.14, 1985, p.289.

method of interaction at desirable stages of the process is examined.

To realize better interfunctional linkage between technology side and market side in terms of the resource, we should discuss (1) what institutional factors do we have to have?, (2) how do these institutional factors work?, (3) how should their strategic management process be implemented? The current system and organization of NTT are analyzed as an empirical basis on this discussion.

3.2 Research Methodology

The methods adopted for this thesis study are a literature search, empirical analysis of a current system, and interviews.

3.2.1 Current System/Organization Analysis

Along with the new process model of technology/business development, some institutional factors are considered for possible change to realize better interaction between the technology side and the market side. The question is (1) what institutional factors do we have to change?, (2) how can we realize the change? For this discussion, I will analyze how the existing system works, focusing particularly on R&D, human resource management, marketing, and service & operations through my own experience and career.

At the same time, detailed information on NTT's R&D-based business development project was acquired from two NTT managers who were involved in the business development projects. This information was examined as a case to compare with the development processes in the literature.

3.2.2 Interviews

Interviews were held with 14 people in three U.S. firms - Xerox, Raychem Corporation, and AT&T. The criteria for company selection were:

- 1) abundant experience of technology innovation,
- 2) active in business diversification,
- 3) excellent marketing, and
- 4) not limited to the manufacturing section.

Xerox is a typical example of criterion (1), Raychem Corporation is a good example of (2) and (3), and AT&T was selected as an example of (3) and (4).

Questions for the structured interviews at these firms are given in Appendix A. The questions examine the following aspects of technology-based new business development:

- a) strategy,
- b) management,
- c) institutional factors, and
- d) technology/product development.

These interviews were supplemented by discussions with MIT Visiting Scholar and other researchers at MIT. They are also listed in Appendix B.

CHAPTER 4

Review of NTT's New Business Development

4.1 Background

4.1.1 Environmental Change

NTT was privatized in 1985. Before that, the management policy was to realize "universal service," with the purpose of constructing a telecommunication network everywhere in Japan, including the far isolated islands. Therefore the major objective of NTT's corporate R&D was to improve the performance of the network system and to cut the cost of investment in its infrastructure. The policy objective was achieved in 1983 and ISDN(Integrated Service Digital Network) became a new long-term target. At the same time, development of new telecommunication services to stimulate the market, and development of new business in addition to the telecommunication services became short-term targets. This is because more than 80% of annual income was dependent on conventional telephone charges and the introduction of a second source of income was thought to be inevitable.

Another objective was the streamlining of management. NTT had 310,000 employees in 1985 and had to reduce personnel dramatically.²⁶ Layoffs are not an appropriate solution within the customary workplace, so another way of coping with this situation was to develop a new business to absorb the surplus workforce. Therefore, creating business and providing employment became the inevitable objective.

Consequently, corporate R&D had two new objectives, that is, the development of new telecommunications service and the development of new businesses.

²⁶ NTT Advertising Department, *NTT Databook '93*, Nov. 1993, p.9.

4.1.2 Position of R&D

NTT's R&D activities extend from material science research to network service development. In 1985, there were 2700 researchers and the budget was \$0.6 billion.²⁷ A schematic diagram of business flow from R&D to Service Operation is shown in Figure 7. Technology and products of Applied Research and Development are transferred to the Business Division, as shown in Figure 7. However, Business Divisions are divided by service and regional area, while Laboratories are divided by technologies. Therefore, a one-to-one relationship between R&D and the Business Division does not exist. In spite of the fact that NTT's main business is a service operation, one-third of corporate R&D is in charge of material and device research and development. This also indicates the weaker correlation between R&D and the Business Division. Before privatization, contribution to academia was a significant part of NTT's *raison d'etre*, but after 1985, its importance diminished except for basic research. So, part of NTT's R&D became less significant in the organization. Therefore, finding a downstream exit for technology outside of NTT was the only way to keep their research objectives for materials and device R&D.

However, debate arose over the validity of using money derived from telephone charges for use in other business objectives. The telecommunication business has public characteristics similar to other utilities' businesses. Therefore, based on that logic, the profit from telephone service should be used for a price reduction of telephone charges. As a result, the direct goal of R&D was still kept as the contribution to the main business, and the application to the other business was considered a by-product.

²⁷ NTT R&D Headquarters, *NTT R&D Information*, 1994, p.29.

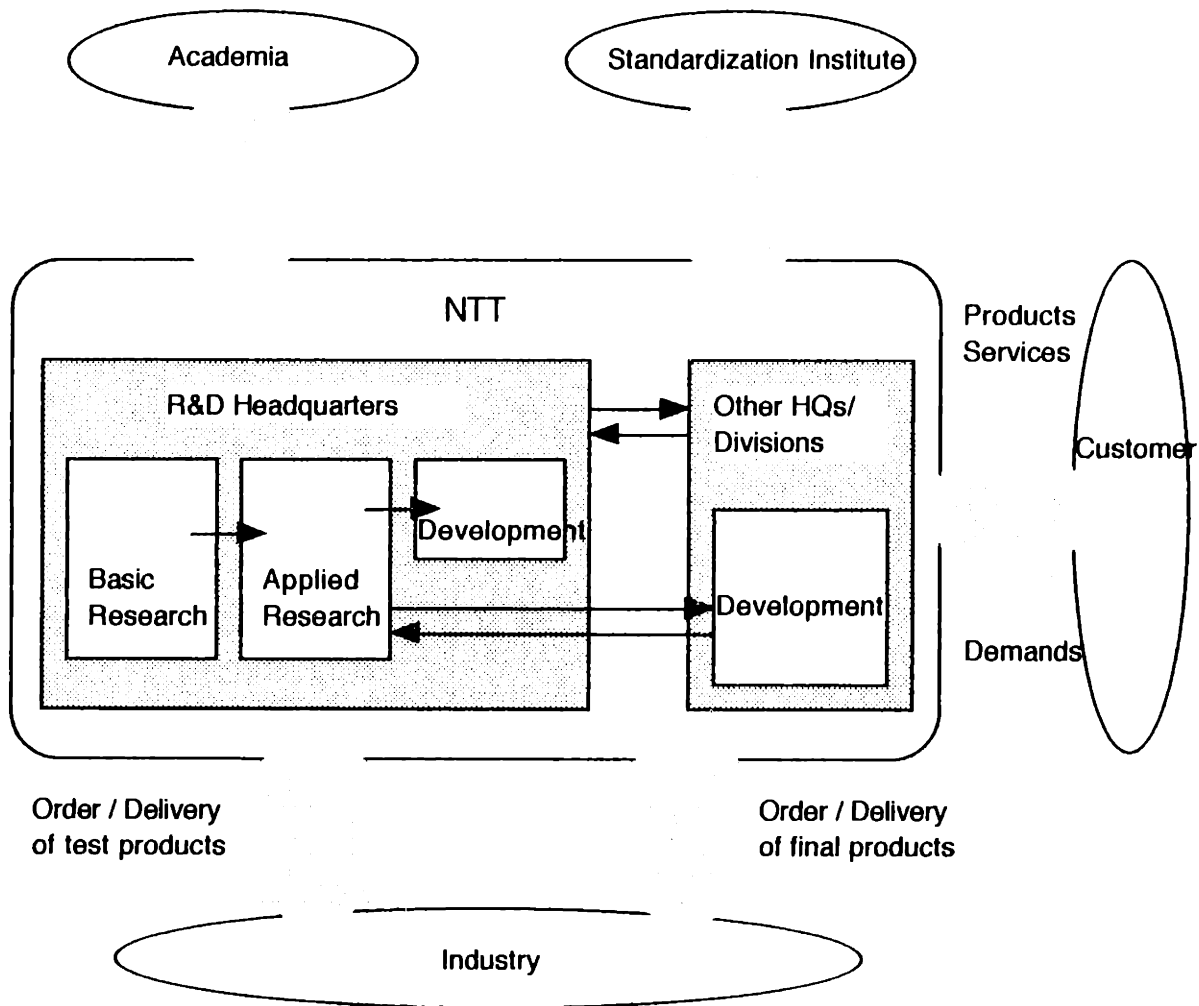


Figure 7 Business flow from R&D to service operations
 (NTT R&D Information, 1994, p.30)

4.2 Organizational and Institutional Issues of NTT R&D

4.2.1 Project Classification

In terms of resources, each R&D project is classified as one of 4 classes: A, B, C and/or D. Class-A projects can use a relatively large amount of resources, but should have a clear and short-term goal and be focused toward the business division's needs. Important judgments are made by R&D Headquarters. In contrast, each laboratory's directors and executive managers have the authority to start class-B or lower projects without Headquarters' permission, corresponding to the amount of necessary resources. This concept is illustrated in Figure 8.

In terms of project phase, NTT management distinguishes 4 phases: R, AR, FD and D. R (Research) indicates a very early stage of the project. AR (Applied Research) is the phase in which the project clears technological milestones and defines the shortest path to the goal. FD (Fundamental Development) phase means the prototyping stage. D (Development) is the final stage of product development.

There is a weak correlation between the 4 classes and 4 phases. C and D class projects have a lower probability of proceeding to the D phase. On the contrary, A class projects usually focus on the D phase from the beginning. Subsequently, this means that there is a need for many decisions at each managerial level.

4.2.2 R&D Plan and Decision-Making Process

In the case of class-A and B projects shown in Figure 8, an official decision-making system exists within the organization. In the case of decision-making system of R&D Headquarters, a couple of business division's managers are involved as regular members. The other business divisions'

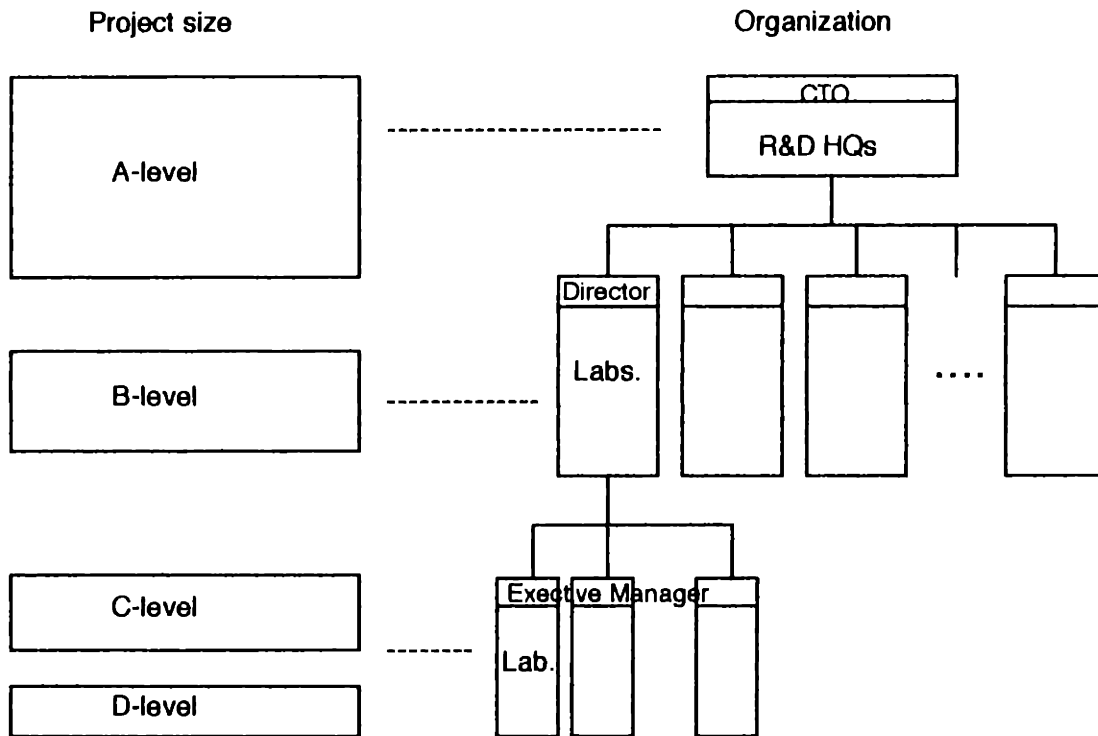


Figure 8 Project class and management levels at NTT

managers are involved in case of necessity. However, they are all technology people.

Every project in the A and B classes has a plan from the start, and must be authorized by the corresponding decision-making system. The plan should include a prediction of expenses, expected results for the coming five years, competitive technology, and future needs. Once a year, a project has an interim check and the plan should be adjusted accordingly. Class-C and D projects can start with a very rough plan and an executive manager's judgment.

4.2.3 Marketing and Service Function

In contrast to U.S. companies, very few Japanese companies have a marketing department. Even if their English brochure shows a department named "Marketing," the actual meaning of its Japanese name and its functions are closer to "Sales." NTT is one such example. Figure 9 shows part of NTT's organization in 1993. The Service Marketing and Support Headquarters' one of major responsibilities is to create a strategic plan of service charges. Marketing-related functions are dispersed among other sections which are shown in the bold squares.

Organizations shown in the grey boxes in Figure 10 are on the technology side and have close relationships with each other. They are regular members of the decision-making system within R&D Headquarters.

The cross-organizational relationship between these two large segments is very weak, and board meetings are the only official place of interaction. This situation is very different from the one Porter discusses in his value chain model.²⁸ NTT need to realize an organic connection between the organization structure and its value chain.

²⁸ Porter, M.E., *Competitive Advantage*, New York: Free Press, 1985.

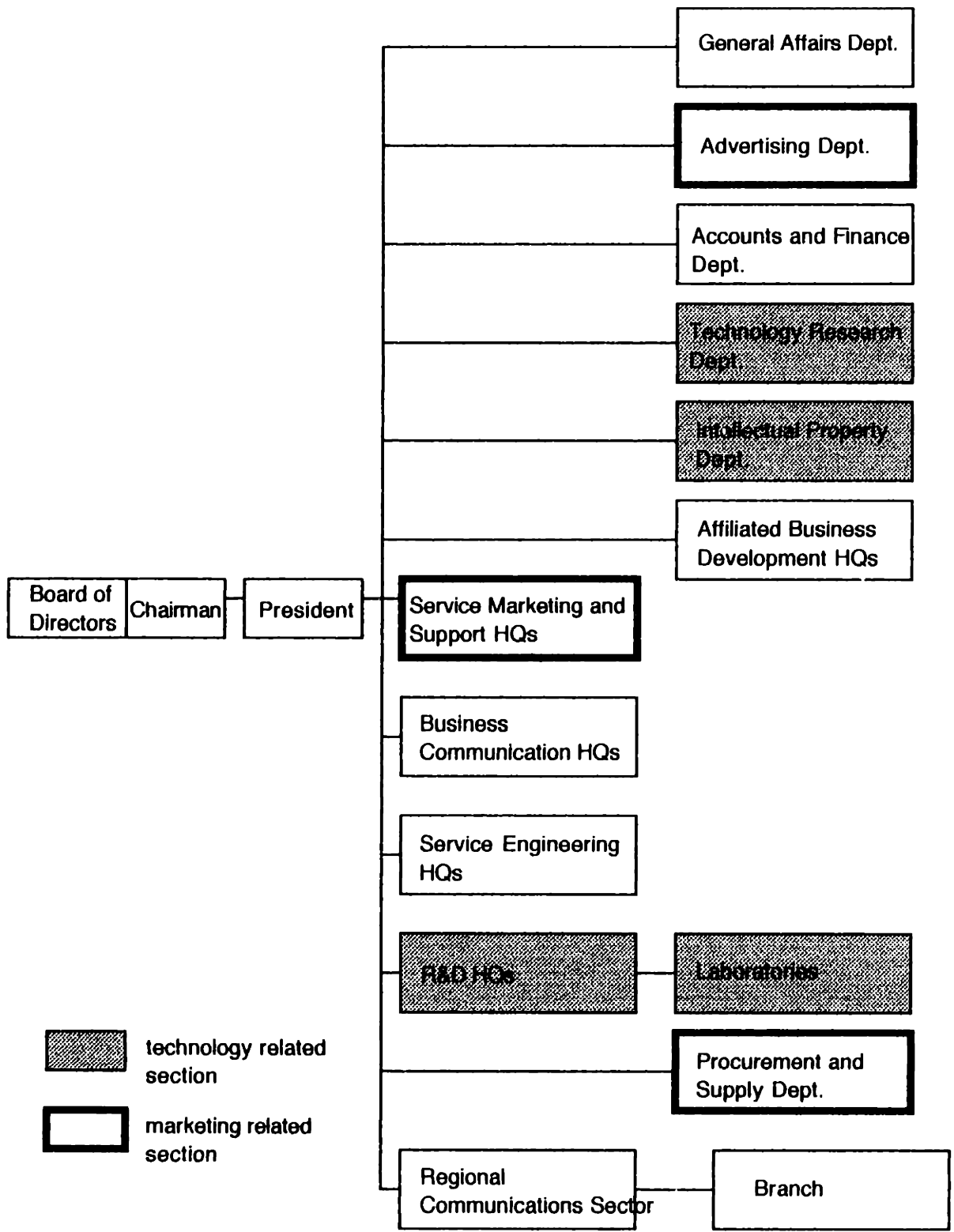


Figure 9 A part of NTT's organizational structure
(NTT Annual Report, 1993)

4.3 Examples of NTT's Venturing

Since 1987, many business development projects has been started, mainly in the device technology field. Major targeted products of these projects and the outline of their activity were as follows:

- a) Optical devices (beam splitter, switch, multiplexer-demultiplexer)

R&D started in 1982. NTT started a JV with Battelle Memorial Institute and Mitsubishi Trading Co. in 1987. The company is in the final phase of commercial product development.

- b) Rechargeable lithium battery

R&D started in 1984. NTT started a JV with MOLI Energy Ltd. and Mitsui Trading Co. in 1989. The venture virtually closed in 1994 at the prototyping phase.

- c) Semiconductor process equipment : ECR (Electron Cyclotron Resonance) sputtering film deposition

R&D started in early '80s. NTT started a JV with Nippon Steel in 1989. The company is currently expanding its business from ECR to other equipments.

- d) Active-matrix LCD (Liquid Crystal Display)

R&D started in 1983. Business development project started in 1989 and finished in 1992. Details are reviewed in the next section.

- e) High speed LSI tester

R&D started in early '80s. NTT started a JV with Schlumberger in 1989 and closed it in 1992.

- f) AI Work Station

R&D started in late '70s. NTT started a JV with OKI Electric Co. and four banks in 1987. Its business has been expanding favorably from AI workstations to computer-related systems and products favourably, and revenues in 1991 were about \$12 million.

All the technological seeds were developed within NTT's R&D. Half of them are still in business, but only one of them

still maintains its initial target and the other two have been changing and expanding their product lines.

4.4 Active Matrix LCD Development

As an example of NTT R&D's venture trials, the LCD development project will be discussed. An historical outline of the project is shown in Figure 10. The top half of the figure shows the history of management, and the bottom half indicates the history of the technology and products.

4.4.1 Start Up

R&D itself started before NTT's privatization. An initial survey, mainly focused on technologies, was performed by a senior researcher. The original objective of R&D was to develop a high-performance display predicting the importance of human interface in visual communication service. NTT's services themselves were expected as a major target, so the plan paid less attention to the market and its trend outside of NTT. When NTT was a public corporation, ROI of R&D was not discussed. However, after 1985, the effectiveness of R&D has become increasingly important, and the meaning of device research in NTT was beginning to be questioned. As a result, the target was changed from applying this research to NTT's visual communication terminals to marketing it to the external industrial market.

4.4.2 Technology Target

The first target was described as an "A4 size active matrix full-color LCD." This means a 15" diagonal size LCD aiming to replace the CRT monitor of desktop PCs. Two technological targets were assigned:

(1) On-glass peripheral circuits, and

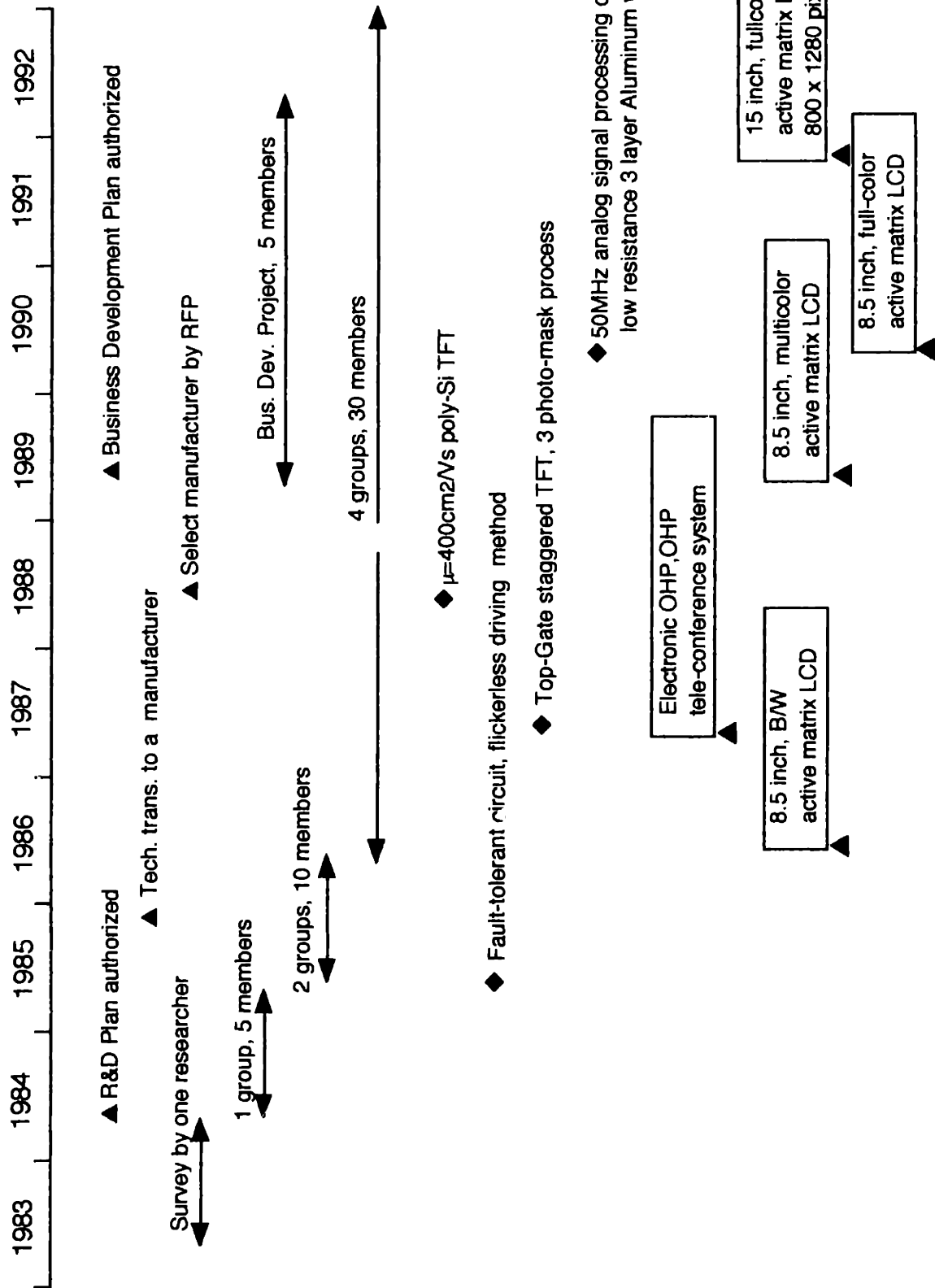


Figure 10 History of LCD development project

(2) Fault tolerant technology.

One goal of target (1) was to realize a low-cost LCD. In LCDs, assembly costs and driver circuit costs make up a significant percentage of the total manufacturing costs. If driver circuits can be integrated on the glass substrate with switching TFTs (Thin-Film Transistors) in each pixel, a 20% cost reduction would be possible.²⁹ A schematic diagram is shown in Figure 11. Using poly-crystalline silicon (poly-Si) instead of amorphous silicon (a-Si) as a semiconductor material, we can make enough performance-driving circuit directly on the glass substrate. The problem was the high processing temperature. Amorphous Si can be deposited at 300 degree centigrade; however, poly-Si requires more than 600 degree centigrade, at which temperature a glass substrate cannot be used. Therefore, we focused on the development of a low-temperature poly-Si process.

The aim of target (2) was to realize a high manufacturing yield. Active matrix LCDs use the same process technology as LSIs. A different problem from LSIs is its long data line length and power line length. These lines are made by photo lithography, and it is very difficult to make a long line without any defects. The defects result in a black or white line or dot in the screen which is not acceptable in a display. The screen image of this defect is shown in Figure 12. In the case of an LSI chip, more than 50 chips can be made at once on one wafer. If the yield is 50%, 25 chips can be used. However, a large display is made one by one, and even if each substrate has only one defect, it cannot be used. Therefore, fault tolerant technology is necessary to achieve a high yield. NTT focused on a new driving circuit which could compensate for line defects.

²⁹ NTT's Research Plan on Active Matrix LCD, 1984.

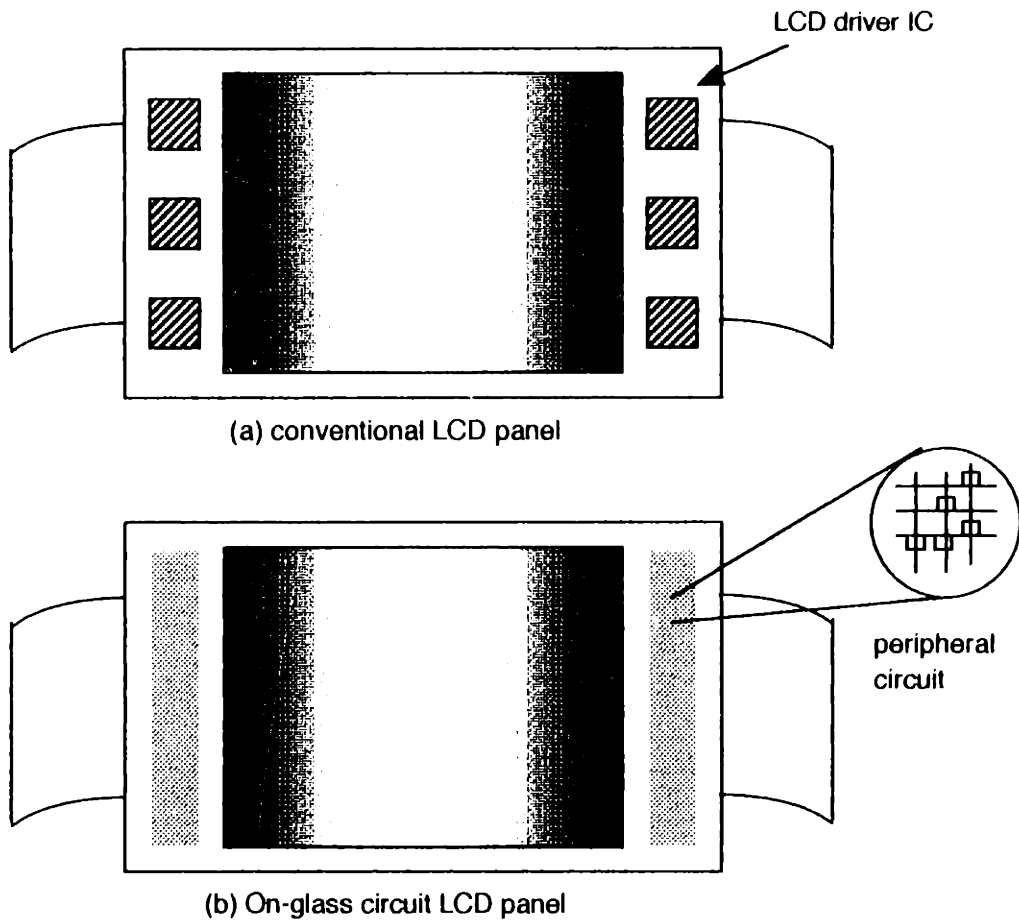


Figure 11 On-glass peripheral circuit

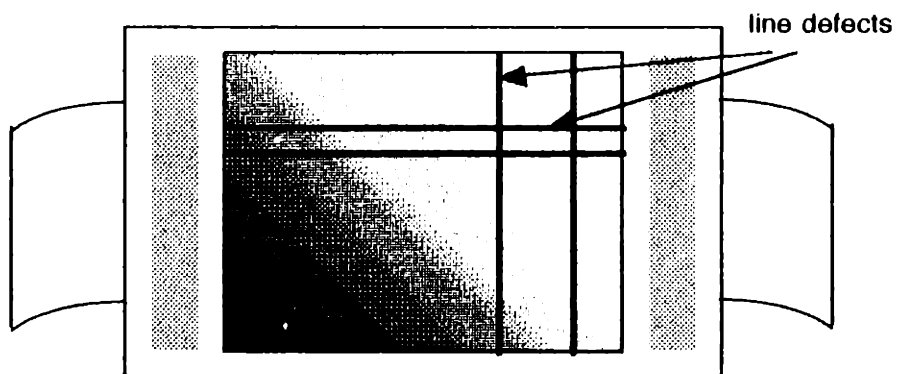


Figure 12 Image of defect

4.4.3 Market and Strategy

The target market was the replacement of CRT monitors in desktop PCs. There was no market prediction at that time, but the production number of personal computers in Japan was estimated as 3,000,000 in 1995. NTT thought that 10% of its CRT could be replaced with LCD if it could be made for \$1000/panel. That price is four times as expensive as conventional CRT, but LCD has the added value of less space and less energy consumption which were considered to be very important in Japan and to compensate for the price gap. Therefore, market size was estimated as \$0.3 billion in 1995.

In 1985, another prediction was made by Sharp Co., who said that the total LCD device market in 1995 would become \$20 billion and 10-inch size TFT LCD's price would be \$500/panel. They set this number as their corporate target very strategically. PC prices were around \$4000 in Japan, therefore, if its manufacturing cost was \$1500, one-third of it would be the maximum cost a PC manufacturer could allocate for display. Based on this logic, the panel price was estimated.

NTT's trial product cost was more than \$10,000/panel at that time. Therefore, a strategic campaign was necessary to convince the PC manufacturers that the LCD cost would drop to a reasonable level to adopt it for their computers.

The other important perspective about the future market was that Sharp and many other manufacturers set their target on the 10 inch size. The reason was the popularity of the lap-top style personal word processor in Japan. The market for notebook-type PCs was still uncertain at that time. However, word processors started to popularize very quickly, even though they used a monochrome TN (Twisted Nematic) LCD, which was cheap but had lower image quality. This suggested a greater possibility of popularizing lap-top PCs and their market expansion.

NTT adopted a strategy of keeping the lead time to two years against the competitors and take a first mover's advantage. This strategy was discussed mainly for the technological target based on the supposition of full market acceptance. NTT thought that following two would be core technologies:

- (1) on-glass peripheral circuits, and
- (2) fault tolerant technology.

Since NTT has no manufacturing, we needed to have a subcontractor or a joint venture partner. For the trial production of the first prototype of an 8.5 inch active matrix display, NTT transferred its circuit technology to a Japanese mid-sized electronic device manufacturer. In the latter stage toward new business development, the same manufacturer was selected again through the RFP (request for proposal) process. NTT took the role of key technology development and panel design, and relied on the partner to manufacture the panels.

4.5 Problem Analysis

4.5.1 Strategy

NTT adopted a "Producer Preference" strategy, one of Goodman and Lawless' nine strategies described in Chapter 2, aiming to get a first mover's advantage.³⁰ While the selection of this strategy may have been correct, its implementation had an important defect. This strategy requires two different actions: one is investment in technology development to overcome a steep learning curve, and the other is to acquire intellectual property rights as much as possible to serve as a barrier to the early entrance of competitors. In terms of the technologies developed by NTT, intellectual property rights were carefully protected by

³⁰ R.Goodman and M.Lawless, *Technology and Strategy - Conceptual Models and Diagnostics*, New York: Oxford University Press, 1994, p.60.

patents. However, NTT's technologies were not enough to improve the yield for the steep learning curve.

Various kinds of knowledge about the manufacturing process should be accumulated in order to realize high yield and this knowledge can only be acquired through recursive processes. Even if NTT had succeeded in developing the world's first 8.5 inch size active matrix LCD in 1986 with more than two years lead time, improving the yield after that was not an easy job. The sample price of that LCD panel was more than \$10,000 and there were no suitable applications for applying such a high cost part. Repeating the process of development without any application was very hard to justify from a financial point of view. And the resulting delay of yield improvement affected decision-making for the start of the business development project.

On the other hand, one of the leading manufacturers, Sharp Corporation, focused on the development of a 3 inch size active matrix LCD first, which was used for portable TVs. Sharp started mass production of the 3 inch size panels in 1987.³¹ Through this process, they accumulated know-how of the manufacturing techniques. Then, they expanded the display size from 3 inch, to 4 inch, and then 5.6 inches step by step. Along with this progression, other applications such as a car navigation system and an 8mm video camcorder incorporated with LCD were also developed. Finally, in 1990 they started the production of a 10 inch size panel.

Consumer electronics products such as portable TVs must be inexpensive, therefore the application of LCD to this field is not very profitable. However, continuous production could be maintained, which helped mature the process technologies and reduce the process development cost of larger size LCDs. These facts clearly show Sharp's investment strategy. They developed not only technologies, but also applications and better environments for customers.

³¹ Nikkei BP, *Nikkei Electronics*, Tokyo, May 23, 1994, p.130.

By contrast, in spite of its "Producer Preference" strategy, NTT failed to devise concrete tactics for how to maintain the lead time.

4.5.2 Market Projection and Analysis

NTT targeted as its replacement market the CRT of desktop PCs. In 1989, the Japanese electronics industry and Dataquest Inc., a U.S. market research firm, predicted that total world PC shipments would reach 40 million in 1995.³² They also estimated that 30%, or 12 million, would use the flat panel display mainly as a laptop PC. Because of Japan's expensive land prices and limited office spaces, demand for the flat display instead of CRT monitor was thought to be significant. Therefore, the potential market for replacement was thought to be very big, if the LCD price could become competitive with CRT prices.

On the other hand, core competencies associated with LCDs are achieving (1) very thin thickness, (2) low electric consumption, and (3) the possibility of full-color display. These features are important for laptop and notebook PCs, because there are no alternatives that satisfy all these factors. When considering replacement, rather than substitution, LCD is best for laptop and notebook PCs. So, the decision was made that NTT should focus on was laptop and notebook PC market.

These two different market segments --desktop PCs and laptop and notebook PCs-- had different targets and problems in planning and implementing the technology and the penetration timing. In the case of replacement, the most common existing CRT size is 14 inches and this size was thought to be a requirement for LCDs. On the other hand, the LCD size required for laptop and notebook PCs is 10 inches.

³² Nikkei BP, *Flat Panel Display '90*, Tokyo, 1989, p.41.

This market had not emerged in 1984 when NTT developed an R&D plan, but was expected to become significant by 1995.

These differences strongly affect the investment strategy and development scenario. Not only the technological difficulty, but also the route to the target in terms of the time scale might be different in each case. NTT lacked this perspective in its strategy.

4.5.3 Development Process and Interfunctional Linkage

All the project processes shown in Figure 10 were carried out in one of NTT's twelve laboratories. The organization of the laboratories in charge is shown in Figure 13. An initial survey was done by a researcher from one group. Then the development project was started by one group of one laboratory. From 1986, the project included four groups. In 1989, a portion of the project was split off as a business development project, which position is parallel to the laboratory. However, all of them are basically in the same management system. Groups in the laboratory were in charge of the substantial technology development, a feasibility study of the target product, and technological support of the business development project, while the business development project's role was the commercialization of the technology and product. This separation was desirable in order to clarify the mission of each member. The business development project was more flexible to perform the commercialization of the product in the laboratories. They could also use an external consulting firm for the market analysis. However, the group management was same with the other research groups and the feasibility study and prototyping were performed with less market information before 1988.

In the technology development phase before 1988, marketing analysis basically depended on the researchers' activity. Like many Japanese firms, NTT has no specific

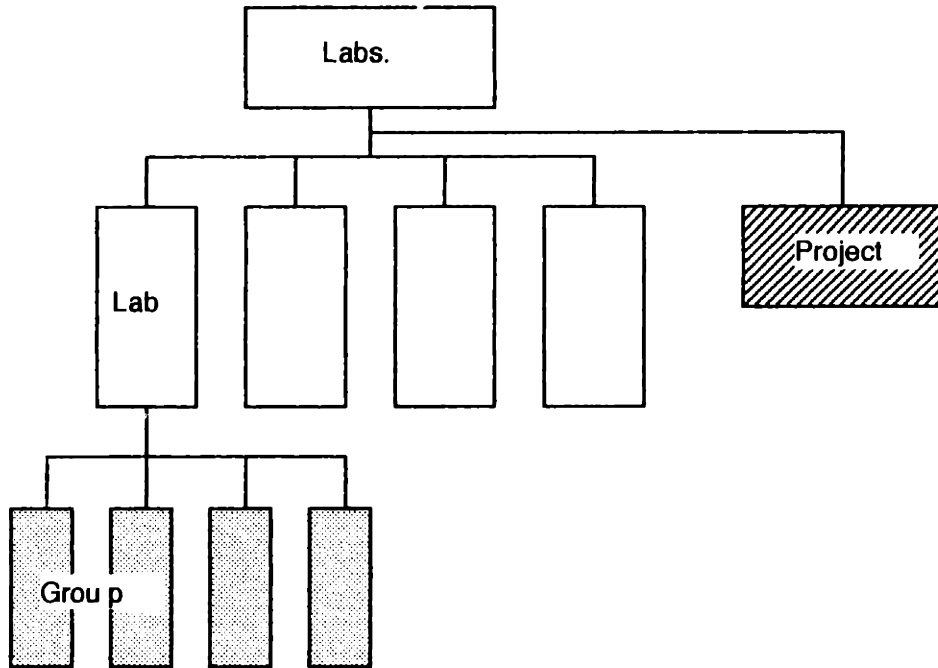


Figure 13 Organization Structure of the laboratories and project's position

marketing organization, and marketing functions are instead handled by many different departments. Moreover, NTT has no manufacturing and no business experience except in telecommunication services. Therefore, there was very little marketing and R&D interaction throughout the process. The assessment of the developed technology was done mainly from the technological viewpoint and there was no specific feedback process to adjust the project direction as the result of marketing analyses. After 1989 the project used an external consulting firm which developed a proper market survey and predictions. However, NTT lacked the ability to analyze data and develop a strategy based on the analyses because of its lack of business experience.

The possibility of an interfunctional linkage with a business unit was suggested. In the case of applications for the telecommunication terminal equipment, the Customer Equipment Department become involved in the project. They planned the LCD application. However, NTT can only choose partners and subcontractors through the RFP (Request For Proposal) process due to the procurement agreement between Japan and the U.S. Also, the partner doing the trial manufacturing and manufacturing for procurement should be independent. This means that NTT could not fix the technology migration path until a later stage of development, even though the business unit has encountered some product planning difficulties in the early technology development stage. Even if R&D shows a prototype of the new technology after trial manufacturing, much uncertainty still exists about product availability for business units and whether it is a feasible business possibility. As a result, no business unit shows any interest in the new technology during the development stage.

4.5.4 Decision-Making System

Since this was a class-A project (as described in Section 4.2.1), every important decision was made by R&D headquarters. Before getting to that level, however, the project agenda has to pass through management discussions at two lower levels. Regardless of its importance, every project is part of the layered organization. If communications in the organization are very smooth, the multi-layer organization is useful for enabling top-down management to share a management policy. On the other hand, there is also a danger of delayed decision-making due to poor communication.

In NTT's case, delayed decision-making was fatal to the project. The project was successful in its trial production of 8.5 inch monochrome active matrix LCD in 1986. NTT had more than two years of lead time over our competitors at that point. Based on that success, the discussion for business development began. However, the discussion of strategy and market focus continued for more than two years. The main reason for this long delay was the difficulty of evaluating the competitive situation because the technology progressed so quickly. Even though there was no announcement of a complete LCD panel development, a great deal of technological innovation had continued. NTT's R&D management did not have any current methodology of structured analysis such as Porter's Five Forces Model, so the competitive situation was analyzed only from the technological viewpoint.

If R&D management had had more effective interaction with the marketing function of an in-house or outside organization, the decision-making process could have advanced more quickly. However, only technology people had continued the discussions in each management level. As a result, the two year lead time was consumed with no viable or marketable decisions reached.

CHAPTER 5

A Study of Three U.S. Firms: Management for New Business Development

To provide a contrast with NTT's R&D management, a field study of three U.S. firms was performed with the expectation of finding different mechanisms of inter-functional linkage between R&D and marketing. Interviews were carried out with 14 people from three firms: Xerox PARC, Raychem Corporation, and AT&T. The dates, addresses and names of these people are shown in Appendix B. The questions used in the structured interviews are shown in Appendix A. These questions concern the following aspects of technology-based new business development:

- a) strategy,
- b) management,
- c) institutional factors, and
- d) technology/product development.

Results from each interview are summarized below.

5.1 Xerox Palo Alto Research Center (Xerox PARC)

5.1.1 Overview of PARC

Xerox is quite famous for its innovative Alto technologies and its failure in commercialization.³³ Since it earned that reputation, Xerox has been making efforts to commercialize its innovative technologies.

Xerox has a clear corporate concept --"Xerox: The Document Company"-- and a technology philosophy of "Digital Revolution" in the last 4 or 5 years.³⁴ These two concepts

³³ Alexander, R.C and Smith, D.K., *Fumbling the Future*, New York: Quill William Morrow, 1988.

³⁴ Sprague, R.A., Associate Center Manager, Xerox Palo Alto Research Center, interview, February 13 and March 14 1995.

replaced "Document System." Such focus is more important for marketing than technology development, but it still acts as a powerful aid in the technology planning process. All research is founded on this concept and philosophy. Xerox has 4 research centers, 4 technology centers, and 8 business divisions. The role of research centers is long-term and rather basic research, and 60% of their research is technology-push, not demand-pull. Yet, even in the case of basic research, a project is begun with the expectation of applying the results to their business divisions.

Xerox is first aiming at systems businesses and does not want to be a component supplier. They recognize that these are two distinct businesses, each belonging to a different field, and the experience from systems businesses cannot be used in the component business. However, in spite of this philosophy, they have been doing device research for a long time. As a result, Xerox employs various commercial methods to maximize its return on investment. One good example is the Laser Diode (LD) business development, described below.

5.1.2 Spectra Diode Laboratories

Since 1971, Xerox has been conducting research on LDs, which are a key component in printing system applications. At first their research was very basic science. In 1981, however, using MOCVD (Metal Organic Chemical Vapor Deposition) technology, the project moved from basic research to applied research with good results.

However, Xerox did not want to carry out the commercialization by themselves because the number of printers Xerox was willing to make was not enough to produce a reasonable volume that would enable cost-competitive LD production. Selling out-of-house is also difficult for Xerox because the components business is very different from their systems business, and Xerox has no sales channel or sales experience. Therefore, Xerox decided to handle the LD

business as a joint venture, SDL (Spectra Diode Laboratories). The partner, Spectra Physics Co., was a firm with gas laser products that planned to enter the solid state laser field. Xerox offered its technology and owned 49% of SDL. Spectra Physics offered personnel and spaces and owned the remaining 51%. Spectra Diode Laboratories has grown quickly, and Xerox earned a healthy capital gain by selling its shares.

One problem encountered in this venturing process was the treatment of researchers. In its best days, there were 18 Xerox researchers, and none of them moved to SDL because of the Xerox's corporate policy. After SDL started, one-third of these researchers did intense technological support for two years. However, after SDL put its business on the track, the project had to reduce personnel because it had achieved its goal. Fewer researchers were required for the new research plan, and there was not another project which could make good use of their expertise. Therefore, many researchers resigned from Xerox. Such a situation is possible in America, which has a high job turnover rate. However, the situation is different in Japan, where changing jobs is not so easy. The effects on personnel when exiting from a current project is always difficult.

Technological familiarity of LD technology is considered to be "New Familiar" for Xerox using Roberts and Berry's matrix (Figure 6). Market familiarity is considered to be unfamiliar, along with the entry strategies described in Chapter 2.3.2. Therefore, a joint venture with Spectra Physics Co. was a congruent strategy. However, we also should consider the "exit strategies" from the viewpoint of long term human resource management.

5.1.3 Technology and Market Development

To maximize the return on R&D investment, the development of a technology migration path is a primary

consideration for R&D management. SDL is one successful case. However, building a joint venture is not always preferable; there are other means as well.

Xerox PARC set up a new organization named Technology & Market Development (TMD) in 1993. TMD includes 7 members, and their responsibility is to scan Xerox's technology and the outside market to find the best business opportunities. Their position is as staff to the Center Manager. As shown in Figure 14 TMD actually proceeds through each step of the commercialization process, but the major part is the "Identifying" stage.³⁵

One product that resulted from TMD's work was the "Liveboard" business. Liveboard is a computerized blackboard that also has a communication function. This is a very important strategic product for Xerox, and it was expected to be positioned among the existing product lines. However, TMD realized that no current business division fit with this product because the target market was so new. TMD decided to create a different organization dedicated to Liveboard, and a wholly-owned subsidiary started business in 1994.

TMD's function is to find the best way to commercialize Xerox's technologies and products (a schematic diagram of this function is shown in Figure 15). Therefore, TMD makes no commitment in the early stages of R&D. Nor are there many other forms of interaction between R&D and marketing like information exchange or collaboration in Xerox PARC.³⁶ This situation is in stark contrast to prior studies which recommend interfunctional linkages between R&D and marketing in the early development stages. Early stage interaction brings projects closer to demand-pull forces. This is important, since market factors appear to be the primary influence on innovation. Utterback found that 60-80% of important innovations have been in response to market

³⁵ Steiger, B., President of TMD, Xerox Corp., interview, Feb. 1995.

³⁶ Sprague, R.A., Associate Center Manager, Xerox Palo Alto Research Center, interview, February 13 and March 14 1995.

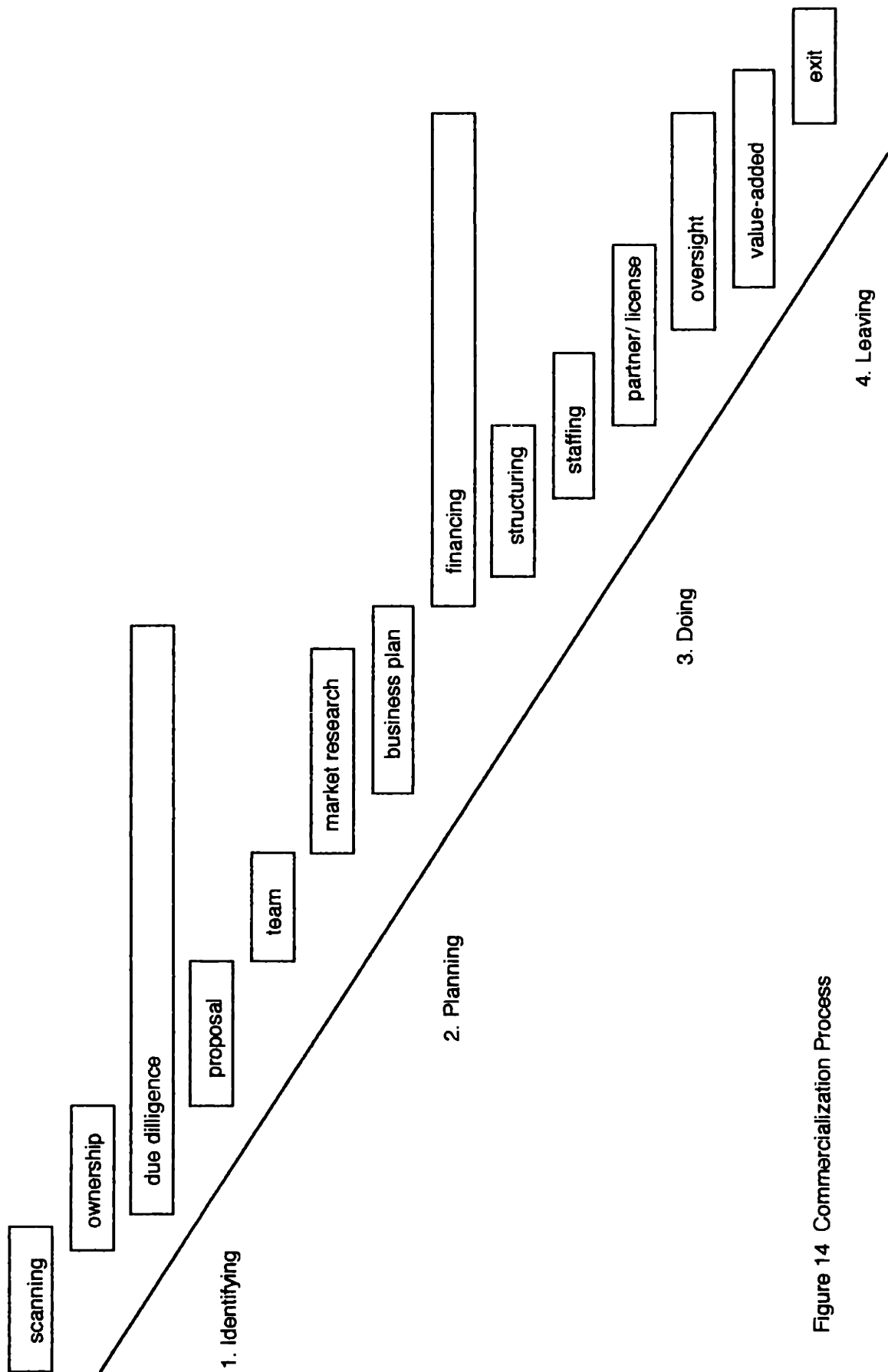


Figure 14 Commercialization Process

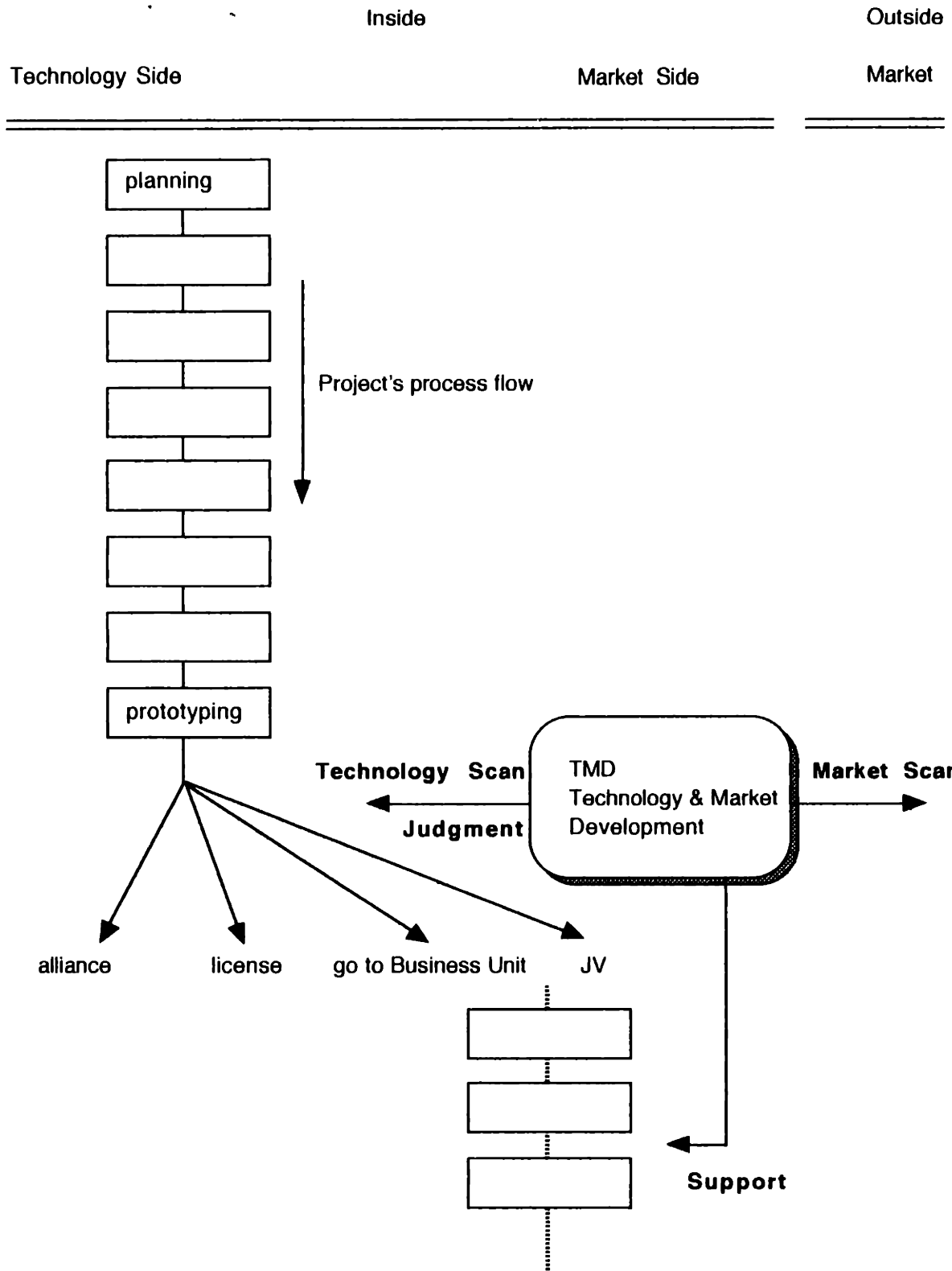


Figure 15 TMD's function in Xerox

demand and needs.³⁷ This tendency was found in eight prior studies including more than 1,800 examples.

TMD, however, found that the success rate of a project could be improved regardless of demand-pull/technology-push, if there was a good system for technology commercialization. The secret of TMD's job is to find an influencer.³⁸ An influencer is a person who can affect the others not only because of his or her title and authority, but also because of his or her character and expertise. He or she should be popular and trusted by the others in the organization. Theoretically, TMD is an outsider for the project and the control of the project is sometimes difficult. However, its policies and objectives can be understood well by the project members through the activities of the influencer. Also, TMD can obtain accurate information of both the inside and outside of Xerox through the influencer.

Xerox's management practices illustrate the effectiveness of interfunctional linkages between technology and marketing in the later phases of development, as well as the role and importance of an influencer. This function also can be combined with the interaction effort in the early development stage, a combination discussed in Chapter 6.

³⁷ Utterback, J.M., "Innovation in Industry and the Diffusion of Technology," *Science*, vol.183 No.4125, pp.620-626.

³⁸ Steiger, B., President of TMD, Xerox Corp., *Interview*, Feb. 1995.

5.2 Raychem Corporation

5.2.1 Overview of Raychem

Founded in 1957, Raychem is a materials science products company with current sales of \$1.5 billion. It has extensive international business, with 70% of its revenues coming from outside the U.S.: 50% of its employees are employed outside the U.S. About 7% of its revenues are spent on all R&D (including business division development), of which 2% goes to corporate R&D. There are 1,200 R&D personnel around the world. Raychem recognizes that R&D is the company's primary engine for growth, and it has literally thousands of products. Its competitive philosophy is "Connect", "Protect" and "Shield."³⁹

Raychem recently analyzed its business portfolio and found its main strength to be in the "Current Market, Current/Extended Technology" segment (Figure 16). Raychem has built up good relationships with their existing customers, whose evaluations of Raychem's new technology are appropriate. Because the investment on the new technology has a great effect on these customers interests. Building such relationships with new customers is also important to them. They believe it is necessary for them to adopt an extended market and a new market, and they have developed what they call an "incubation system" for realizing that objective.

5.2.2 Incubation System

Raychem has what they call an incubator for successful new product development. When a project develops promising technology or products, the project is transferred from R&D to the incubator. From an organizational point of view, the incubator is part of R&D and is under the control of the V.P.

³⁹ Raychem Corporation, *Annual Report 1994 and brochures*

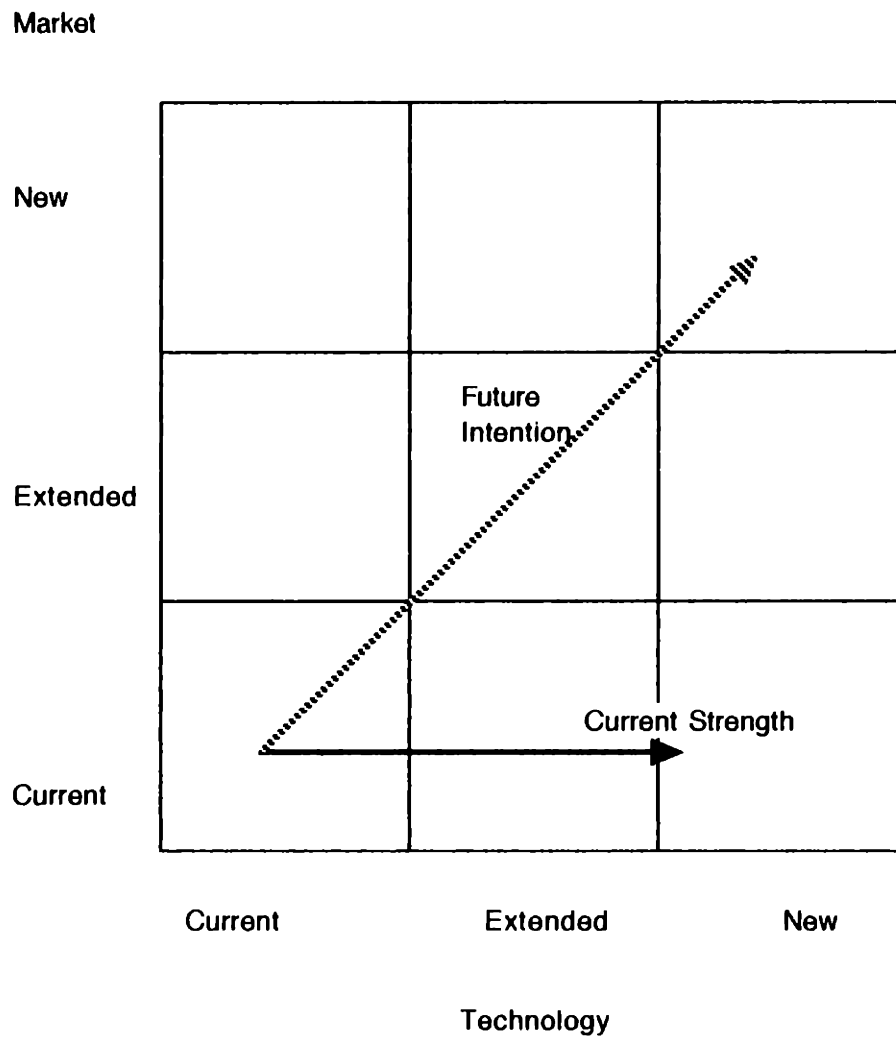


Figure 16 Portfolio analysis of Raychem's business

of Corporate Technology. However, a person in the business division becomes a leader of the project, and he is under the control of his parent organization. Therefore, mixed management is applied to the projects. This system is shown schematically in Figure 17.

Raychem's high voltage insulator is an example of a successfully incubated project. The weight and size of the new insulator was reduced to one-fourth that of existing insulators by developing new materials. In the R&D phase, they developed these new materials. Then the project did the prototyping and field tests for air pollution repeatedly in the incubator. At the same time, the project did market research. A field test was difficult to carry out in the laboratories, because it did not sound attractive to corporate researchers, and it is difficult to motivate them with an unattractive job. However, the mission of the project toward business development becomes much more apparent in the incubator and the project can then remove such a motivational problem. Researchers can do it without feeling out of place in the incubator. Because of these activities, this new product was successfully accepted by the market.

Raychem's system shows the effectiveness of creating an organization independent of R&D in the product development stage. NTT has faced some difficulties in personnel management at this phase because of the mixture of research projects and product development projects. Technology R&D and product development have different management requirements, and a system like Raychem's incubator offers one solution. Moreover, it clearly shows the effectiveness of the human bridge between R&D and business units. Therefore, I include these two factors - independent organization and human bridge - in my new process model of corporate venturing.

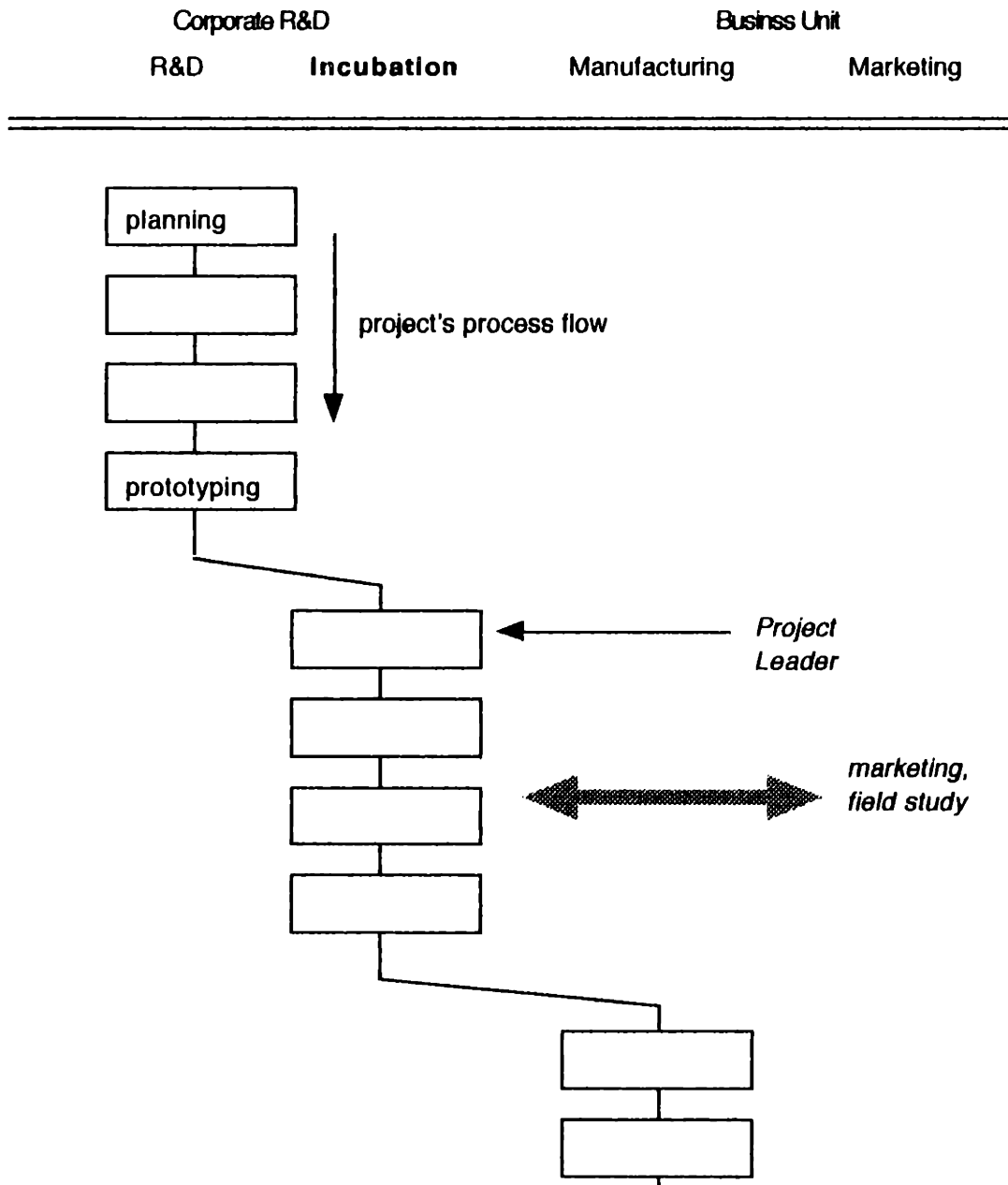


Figure 17 Incubation system in Raychem

5.3 AT&T Bell Laboratories

5.3.1 Overview of AT&T Bell Laboratories

Since the breakup of the Bell System in 1984, Bell Labs' primary mission has shifted to ensuring that the new AT&T business units receive the technological advances needed to provide high quality products and services in a fast changing, competitive environment. Its current mission is to design and develop the information movement and management products, systems and services needed by AT&T; to provide the technology base for AT&T's future businesses; to search for new scientific knowledge, and to apply sound R&D techniques to AT&T's manufacturing facilities. Bell Labs has 1,300 Ph.D scientists and 25,000 employees altogether, with an annual budget of \$3 billion. Eighteen facilities are in the U.S. and 17 overseas.⁴⁰

Bell Labs' R&D focuses on three key sciences of the Information Age - microelectronics, software, and photonics (lightwave) - and for engineering these sciences into the basic technologies common to AT&T's markets: networked computing, wireless, messaging, visual communications, and voice and audio processing. About 6-8% of R&D resources is used for pure scientific research.

5.3.2 Decentralization

Bell Laboratories tends to pursue targets that are necessary for AT&T's businesses after the AT&T divestiture in 1984. They were decentralized and built a tight and dedicated linkage with each business unit. Its organization information and management information are not publically open. However, a schematic organization chart (Figure 18) can be deduced from information in annual reports and from

⁴⁰ Frankel, P.J., Vice President, WorldPartners Company, Interview and Private Communication, Feb. 17 and March 30 1995.

interviews with several informants.^{41,42,43} One part of Bell Labs, drawn parallel with the other groups such as Global Information Systems, has responsibility for pure scientific research. All the other parts of Bell Labs are physically in the same location, but they logically belong to the business units. At this level, a person called GTO (Group Technical Officer) is responsible for their technology. He or she is linked with the top level of Bell Labs, and this linkage creates a matrix structure. In the case of a business unit in the Consumer Products Group, marketing, R&D, and so on are working together in product development. Therefore, AT&T's R&D collaborates with the other functions throughout the development process. In the other groups, different types of team work like regionally based activities are carried out corresponding with the business characteristics. As a whole, team work is the basis of their activities.

5.3.3 Marketing Service Description System

Another specific feature of Bell Labs' management is a special project planning system that uses a document named MSD (Marketing Service Description).⁴⁴ It is a short (1 - 2 pages) description of the R&D target written by marketing people. The first stage of Bell Labs' technology development process starts from this MSD which includes information about product, price, market, position in the market, competitive situation, desirability, etc. After receiving MSD from marketing, technologists review the technological possibilities and importance. Through a joint examination by

⁴¹ Simon, S.A., *After Divestiture*, New York: Knowledge Industry Publications, Inc. 1985, p.28.

⁴² AT&T, *1994 Annual Report*.

⁴³ Staudenmayer, N., Doctoral Candidate, MIT Sloan School of Management, *Interview*, April 24, 1995.

⁴⁴ Frankel, P.J., Vice President, WorldPartners Company, *Interview*, Feb. 17 and March 30 1995.

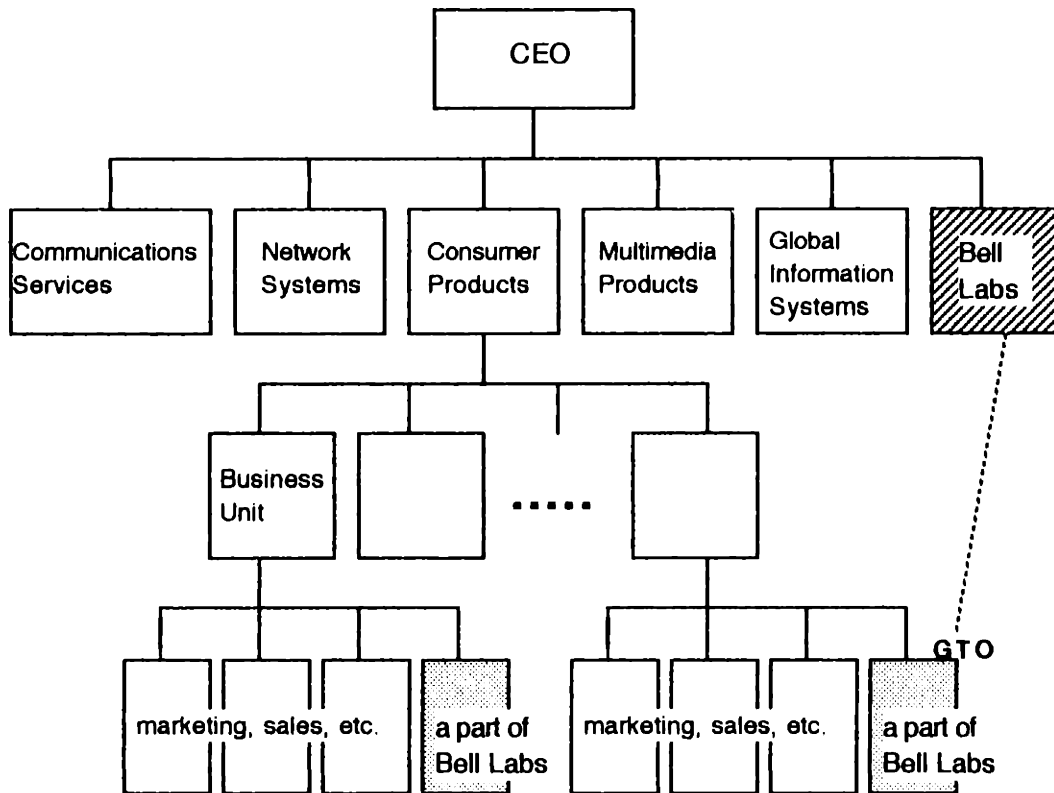


Figure 18 Schematic diagram of AT&T's organization and Bell Labs' position

both marketing and technology representative, a concrete project target is set.

This interaction between R&D and marketing occurred in the very first stage of the development process. This approach is very similar to the published studies presented earlier. For example, Bonnet examined R&D and Marketing cooperation and built a "design link" framework, shown in Figure 19.⁴⁵ It describes the process of planning and decision-making in the product design stage. Careful linkage of R&D and marketing makes it possible to select better functions and technological characteristics. Bell Labs' MSD clearly works as both a market support link and product design link.

5.3.4 Benchmarking System

In 1988, the Bell Labs Council issued guidelines for interpreting the AT&T quality policy. Quality was defined in terms of interval, cost, and performance of its services. Based on this policy, a benchmarking activity was initiated to evaluate quality progress in Bell Labs' R&D.⁴⁶ Figure 20 illustrates AT&T's benchmarking process. The R&D Council solicits inputs from the business units and R&D process teams to define foci of benchmarking. A benchmarking team is then established to conduct the required data collection and analysis. The team includes members across Bell Labs whose functions are well-aligned with the focus area. The team conducts its analysis and feeds the recommendations back to the Council. The Council works with the business units to establish action plans, which are disseminated across the whole R&D. Business units and the associated parts of Bell

⁴⁵ Bonnet, D.C.L., "Nature of the R&D/Marketing cooperation in the design of technologically advanced new industrial products," *R&D Management*, vol.16 Feb. 1986, p.117-126.

⁴⁶ Bean, T.J. and Gros, J.G., "Quality in R&D : R&D Benchmarking at AT&T," *Research Technology Management*, July-August 1992, pp.32-37.

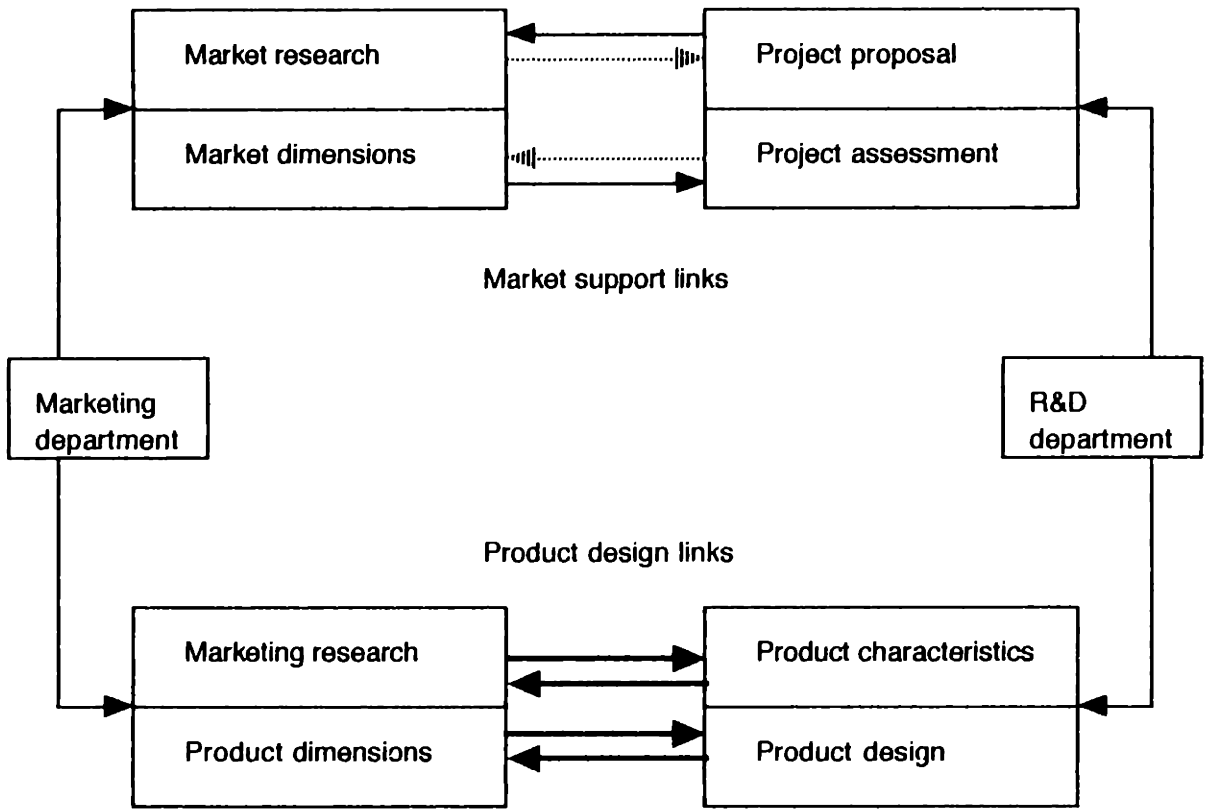


Figure 19 Design link (Bonnet, 1986, p.122)

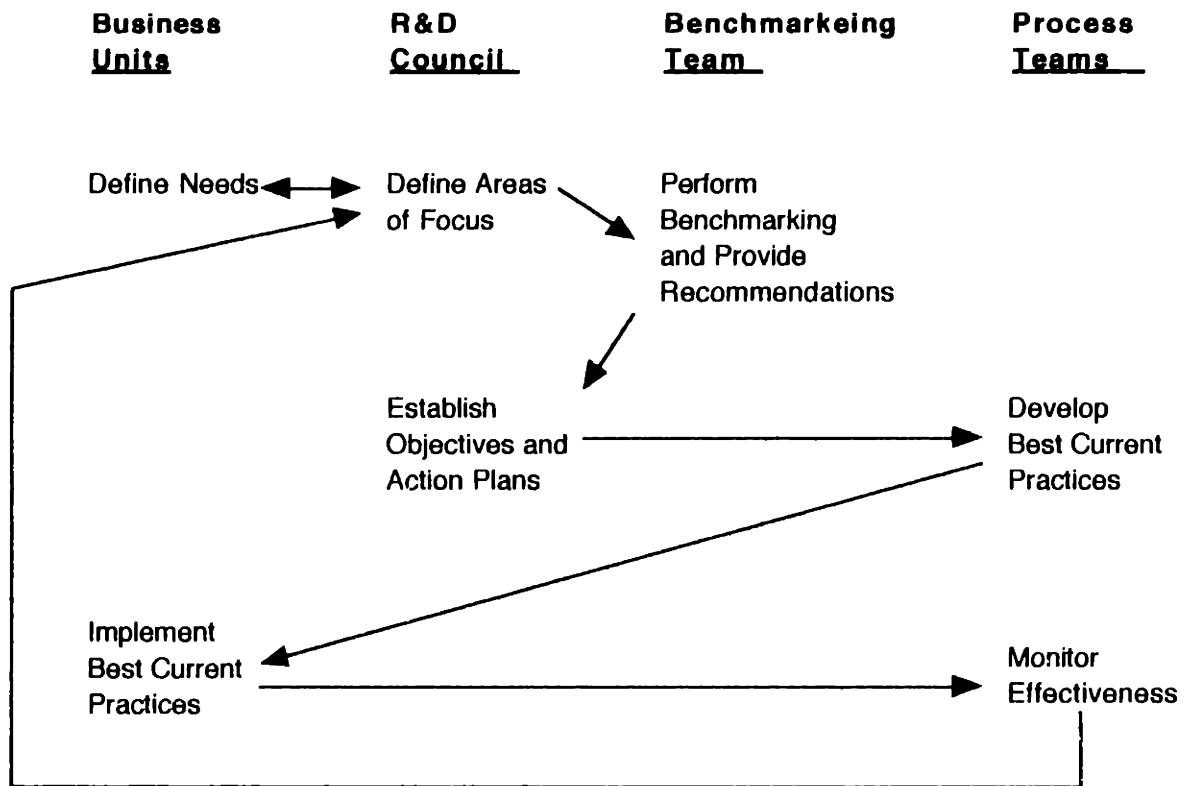


Figure 20 Benchmarking proces in AT&T R&D
 (Bean and Gros, 1992, p.33)

Labs implement these practices and work with the process teams to monitor their effectiveness. This system has been effective in improving the rate of new products introduction. As a support mechanism, a benchmarking information sharing system was developed. All the information is accumulating in a variety of electronic and paper databases available across the laboratories.

Another feature of Bell Labs' R&D process is the effective utilization of external resources. The pre-divestiture Bell System was a self-sufficient organization.⁴⁷ From R&D to services operation including manufacturing by Western Electric, Bell System did the entire process by itself. Such self-sufficiency worked then when fewer services were offered. However, now AT&T has a very diversified service menu, and the self-sufficient system is no longer workable. Therefore, they decided to take advantage of external R&D and manufacturing resources as much as possible. This is also an another linkage between R&D and the outside of R&D.

As a whole, careful multidisciplinary teamwork is realized throughout the development process. Compared with the R&D process before divestiture, a more effective transition of technology into the market is one difference. On the other hand, Bell Labs has some problems with long-term research because of this decentralization. Their situation requires balanced management.

⁴⁷ Bradley, S.P., Hausman, J.A., and Nolan, R.L., *Globalization-Technology and Competition*, Cambridge, MA: Harvard Business School Press, 1993, p.314.

CHAPTER 6

A New Process Model of R&D-Based New Business Development

6.1 New Process Model

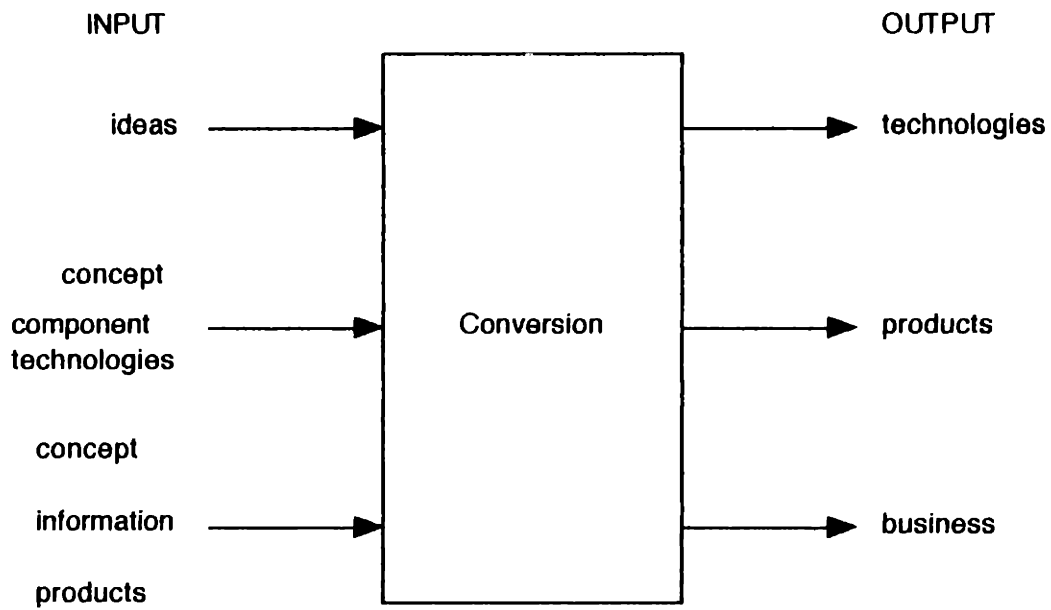
Based on the literature study and field interviews, this chapter develops a development process model directed towards NTT's experiences.

Figure 21 illustrates the two basic perspectives of the development process first introduced in Chapter 2. The first is that technological innovation is represented as a conversion process of inputs into outputs.⁴⁸ For example, an idea and knowledge are inputs and usable technologies are the output in the case of technology development. This idea is also applicable to product development and business development. Concepts and component technologies are converted into products. Business concepts, market information, and products are converted into a new business. To achieve a better conversion, actions such as design, planning, development and examination must be combined properly.

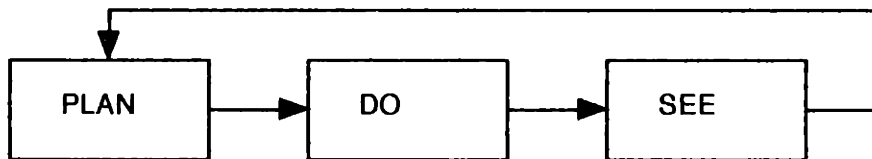
The second perspective is the action flow of Plan-Do-See in the development process. Every development process is a repetition of Plan-Do-See. Here, each step implies the following actions:

Plan	-situation analysis -time scheduling -team making	-target setting -financial planning -other
Do	-design -patenting -marketing -plant construction	-problem solving -prototyping -sales -other
See	-evaluation and analysis -customer surveys	-benchmarking -other

⁴⁸ Twiss, B, *Managing Technological Innovation*, London and New York: Longman, 1986, P.4.



(a) Innovation as a conversion process



(b) Development action principle

Figure 21 Two perspectives of the development process

Using these perspectives, each development process step is examined in detail. In order to analyze the interfunctional linkages that occur during the development process, five major corporate functions were chosen that are relevant to development activities in a technology-based business: administration, R&D, technology development, manufacturing, and marketing. While there are other corporate functions, I have chosen these five as most useful for the analysis. Each process is then diagrammed to illustrate the suggested interfunctional linkages between these corporate functions.

6.1.1 Technology Development Process

The technology development process is carried out in the technology arena, so the conversion process is technological. The inputs are scientific knowledge, needs information, ideas and existing relevant technologies. From these inputs, a concept of the targeting technology must be visualized. This conceptualization is like translating technological characteristics into a common language for non-technical people, as described in Chapter 2. The major conversion process is technological problem-solving. This problem solving and conceptualization correspond to actions in the "DO" step in Figure 21(b). For these actions, additional appropriate interaction with the other functions (as shown in the "design link" in Figure 19) is necessary in the planning stage and prototyping stage. All of these relationships and process steps are illustrated in Figure 22.

Since this process is performed in the technology arena, interactions between the project and technology sides occur naturally. Therefore, the primary need is to develop the interaction path, system and timing between the project and marketing function. As shown in Figures 5 and 19, correct market information gives accurate information inputs for technological design to R&D, and correct interpretation of

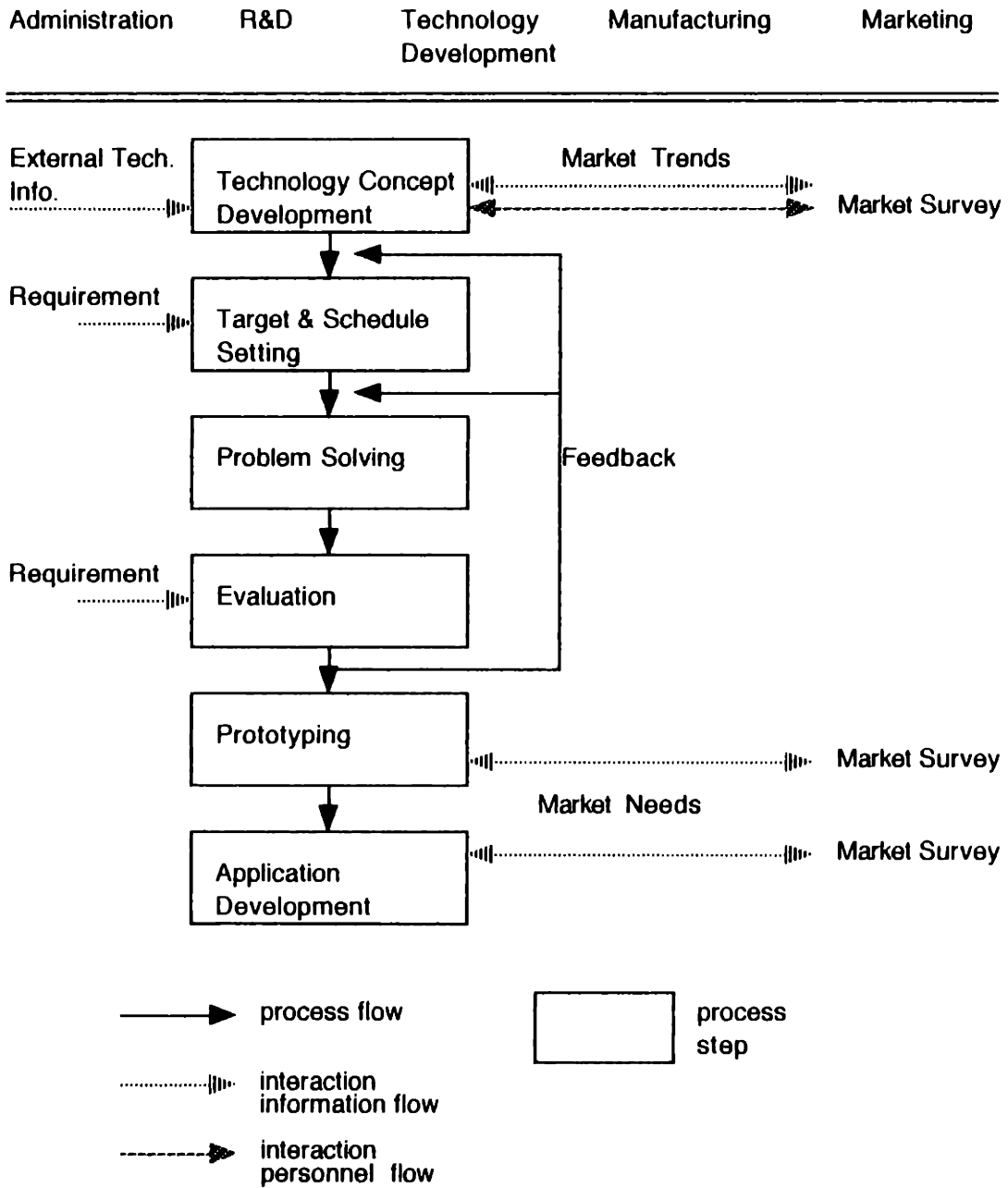


Figure 22 Technology development process model

technology affects market analysis and development as well. This interaction should also happen in the planning stage to develop a better technological concept and to set a correct target and schedule.

In the case of AT&T, a marketing person makes a proposal to R&D, as described in Chapter 5. This approach clearly makes its target a short-range one, and there may be some risk that it will obstruct a long-term strategic project. Also, sometimes a newly developed concept may be described in technical terms and then the technology side takes a strong leadership role at this stage. Moreover, the leading edge technology market is sometimes unfamiliar to the existing business units and their personnel. Therefore, the existing business unit and the marketing section are not always appropriate partners to link with R&D. A more preferable methodology in this interaction is joint fieldwork between technology and marketing people, often including external professional marketing firms. This joint research is similar to 3M's "Joint Upfront Customer Research."⁴⁹ After the prototyping stage, fieldwork by marketing people only is possible because the technological features have been clearly visualized. But the concept of the targeting technology is still vague in this early stage, and joint work by technology people and marketing people is inevitable.

Target-setting, problem-solving, and evaluation are in the feedback loop process. Not only from the technological viewpoint, but also from the users' point of view, the advantage and performance of the results should be evaluated. Evaluation must be done by internal people for strategic reasons. In NTT, this evaluation process occurs in an official meeting with members of R&D and the Business Units. However, the official evaluation process is sometimes inflexible and difficult to change, so "loose control" is

⁴⁹ Sonnack, M., Division Quality Associate, 3M Commercial Office Supply Division, Interview, March 13, 1995.

preferable, as described in Chapter 2.1.1. Unofficial, frequent interaction via telecommunications media is better for flexible, quick feedback.

Prototyping and application development are the bridges to the product development process. From this stage, visualization of technology and understanding the market needs become more important.

6.1.2 Product Development Process

The product development process should be positioned closer to the market side, as is the technology development process closer to the technology side. For better conversion from technology to products, more reliable market information is necessary as an input. Another difference with the technology development process is the importance of a multidisciplinary team. As Takeuchi and Nonaka point out, marketing and manufacturing people should work together.⁵⁰ This means personnel interaction is more desirable rather than information interaction. Moreover, the linkage of a higher-level person is more valuable for considering competencies and the environment, as argued in Chapter 2.1.2.

Raychem's system is one example of a multidisciplinary team bridged to a high-level executive. Many companies have an organization equivalent to a Technology Development Center which is positioned between R&D and manufacturing. This type of organization's objective is to enable a smooth technology transfer from R&D to manufacturing. However, it also may be effective by creating a multidisciplinary team and making team members realize that their mission is different from the technology development.

I propose transferring the project from R&D to a different entity like a Technology Development Center at this stage. The organization of such a Technology Development

⁵⁰ Takeuchi, H and Nonaka, I., "The new new product development game," *Harvard Business Review*, Jan.-Feb. 1986, pp.137-146.

Center is examined again later. If the product's features clearly match with those of an existing business unit, then the project should directly go to the business units' development section. On the other hand, if there are other business possibilities for the product, an organization like Technology Development Center must not be a part of the existing business units.

A preferable development process is diagrammed in Figure 23. Here, an intermediate organization is proposed and the project is transferred into this organization from R&D at the last stage of technology development. The first overlapped stages indicate the connection with the technology development process model. The whole process is a repetition of "Plan-Do-See". From the concept development stage, manufacturing and marketing people must join together in a multidisciplinary team. In the feasibility testing stage, field surveys will be performed by the team. Even in the case of "internal development strategy," constructive use of external technology for some parts of the product is effective because of rapid technology changes. Therefore, access to the external technology is necessary.

For the manufacturing process design and development, process engineers should be involved in the project. This is also a personnel-level interaction. On the whole, a multidisciplinary team is one key to realizing better interactions between the project and the outside. At Raychem, the project leader changes from an R&D person to a business unit person. However, business and manufacturing people are also necessary as team members. Again, senior level representation is preferable.

6.1.3 Business Development Process

Drawing on the process analysis shown in Figure 3, a new model for venturing is presented in Figure 24. The project executes the technology development process and product

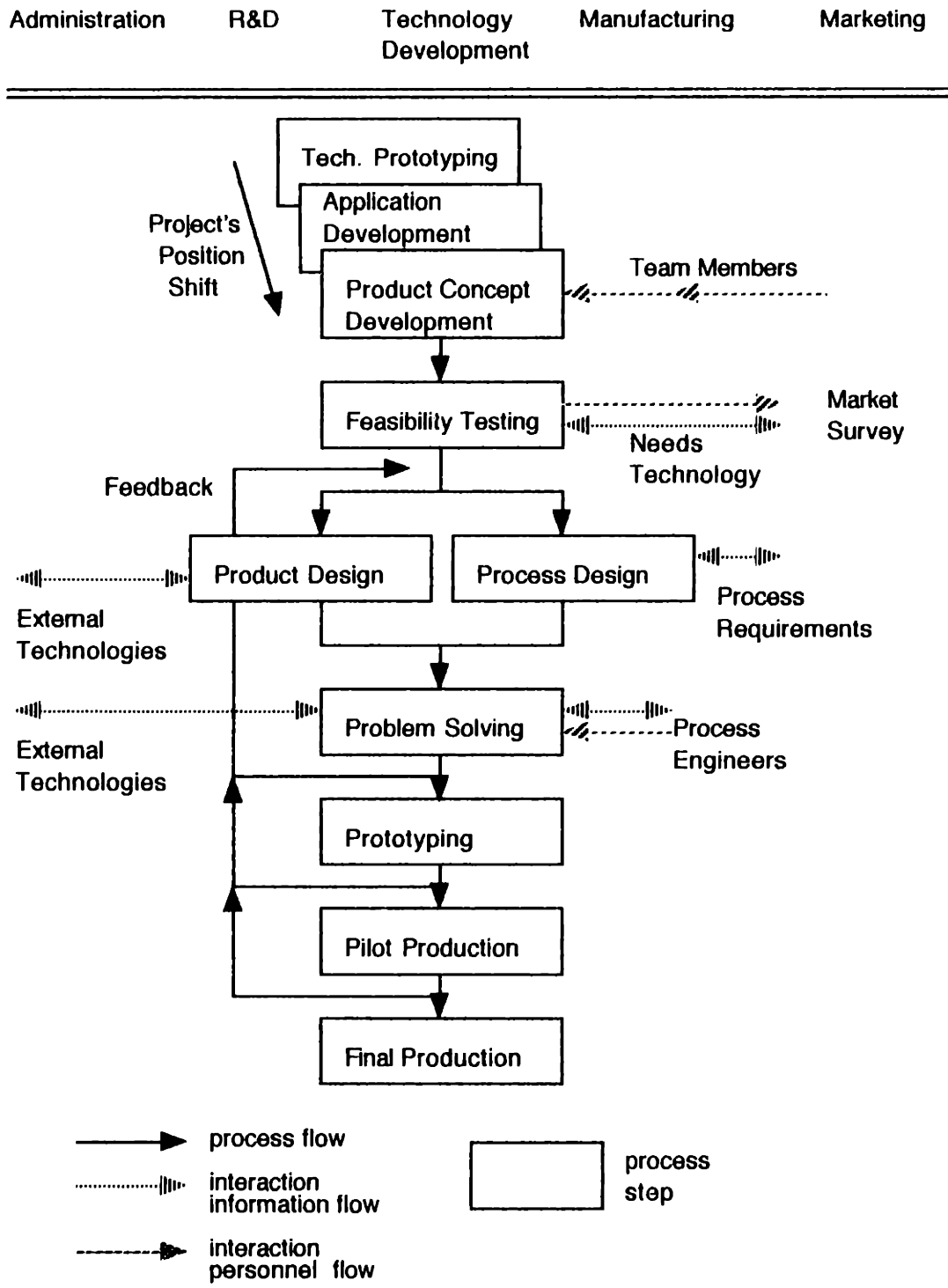


Figure 23 Product development process model

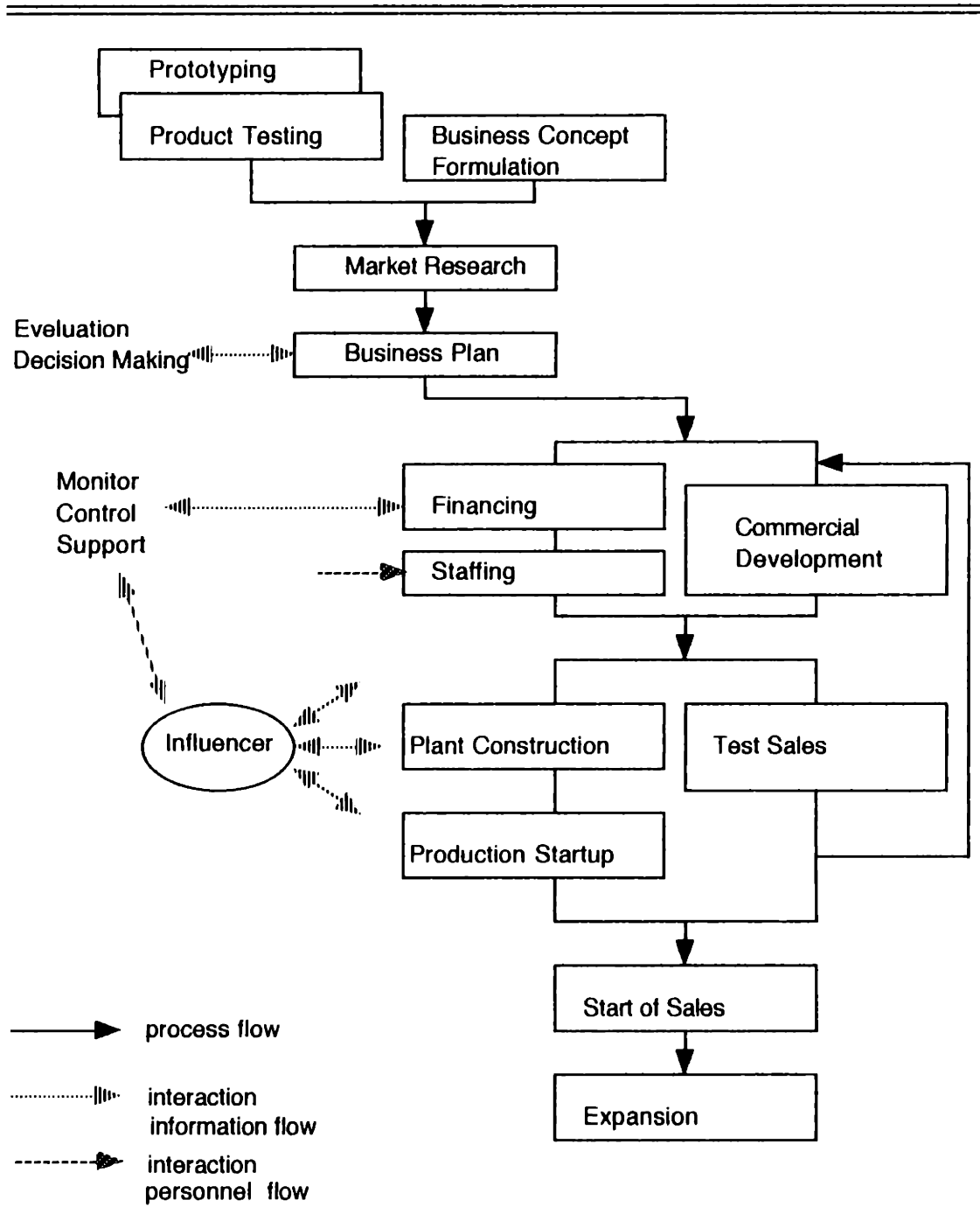


Figure 24 Business development process model

development process within a parent organization. Its position shifts from the technology side to the market side as the process is proceeds. In the case of venturing, however, the project becomes independent from the parent organization after the development of the business plan. Therefore, the relationship and interaction between the venture and the parent organization are also important factors for successful business development.

Again, the first overlapping stages indicate the connection with the product development process model. Business concepts can be developed in earlier stages, but the concept becomes more reliable after receiving the prototype information. The market research for the business development phase must be more precise and detailed compared with other development processes, and should be carried out with an external professional firm in order to increase objectivity. For the most effective research, the project should prepare detailed information about products, possible capital, and preferred strategy.

After the business plan is authorized by the parent organization, the venture starts in earnest. The parent organization must be careful not to overcommit to the venture management, and the venture should not rely on the parent's financial support too much. In NTT's case, a large percentage of the venture management's time was occupied by reports to R&D Headquarters and the Affiliated Business Development Headquarters. To offset such tendency, Block and MacMillan suggest using a "playpen" approach to venture control rather than a "harness" approach.⁵¹

Xerox's TMD system also carefully avoided the problem of overcontrol. According to the President of TMD, the key to their success was to find an "Influencer." This means that TMD's commitment is basically indirect, and they control and support the project through the influencer. Therefore,

⁵¹ Block, Z. and MacMillan, I.C, *Corporate Venturing*, Harvard Business School Press, Boston:MA, 1993, p.231-282.

grooming employees to be key people or "influencers" is important. This person can then be assigned as a member of the venture or to a relevant position in the parent organization.

6.2 Interfunctional Linkage and Strategy Planning

A schematic diagram of interfunctional linkages during the total development process is given in Figure 25. Two different levels of interfunctional linkages--personnel interaction and information interaction--operate throughout the development process. At the personnel interaction level, three different modes can be considered: 1)collaboration within a multidisciplinary team, 2)personnel transfer, 3)mediation by experts and special organizations. In general, these personnel level linkages are more effective than the information linkages for interactions between different functions.

In the case of the technology development process, the importance of a multidisciplinary team is not as vital compared with later stages. However, the interpretation of technical terms into a generally understandable description is necessary for the market analysis. Also, joint work between technology and marketing people is preferable to separate work. No personnel transfer is necessary, but a systematized joint survey will work for this stage in any case. The importance of the interfunctional linkage in later stages is closely related to strategy planning.

According to the description in Chapter 2.3.3, entry strategies can be decided based on the relative technology and market familiarity of the project. Technology familiarity is easily tested in the early development stage. However, market familiarity depends on the product concept and business concept. Also, the competitive situation for both technology and market must be considered as part of

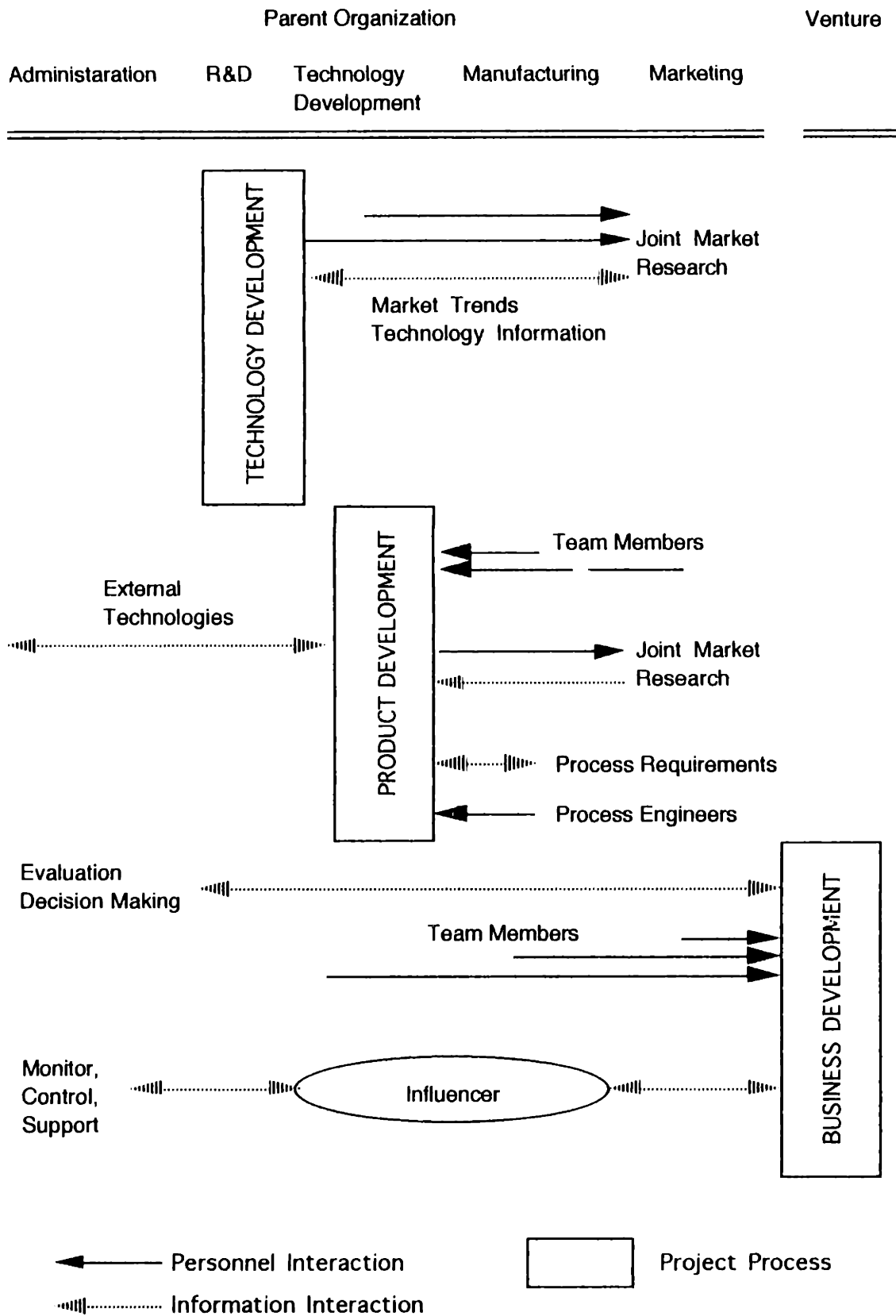


Figure 25 Schematic diagram of interfunctional linkage

strategy planning, as shown in Chapter 2.1.2. Therefore, technology and its market have an intricate relationship with each other, and the interfunctional linkage between the technology side and the market side of the organization is central for the strategy analysis.

The business development process model shown in Figure 24 is drawn based on an internal development process. However, other strategies like acquisitions and licensing are recommended when familiarity is less in both the technology and market, as shown in Figure 4. This is when the external company survey step is needed after the "business plan" step in Figure 24. Such a survey and evaluation requires special knowledge, experience and skill, as found in TMD at XEROX PARC.

A similar process change will happen with the technology strategies described in Chapter 2.3.1. For example, if the product fits the mass market and the project adopts "productive efficiency" strategies, investment should focus on the manufacturing process to obtain productive efficiency. On the other hand, if the product has extreme technological advantages compared with substitute products, investment should focus on R&D to maintain first mover advantages. This analysis should be done in the Product Concept Development and Feasibility Testing Stages in Figure 23 to go forward directly into the Product/Process Design Stage. This strategy analysis also requires market analysis and an examination of product competitiveness. Therefore, interfunctional linkages become even more important in these stages.

The efficiency of the information interaction depends on individual activities. Therefore, assigning to the project a person who can be a Market Gatekeeper or an Sponsor is a

basic requirement.⁵² A market gatekeeper is an engineer or a marketing person with a technical background, who can focus on market-related information sources and communicate effectively with his/her technical colleagues. A sponsor is an experienced senior who can help subordinates and speak on their behalf to top management, enabling ideas or programs to move forward in an effective way. Even though the project may have such key people, some institutional factors are still necessary to facilitate active communication. Allen shows that a closer physical location is one solution to communication problems.⁵³ Another possibility is a telecommunications tool. Carlene Ellis, Corporate Vice President of Intel Corporation, spoke about the effectiveness of visual communications for the management of a world-wide facility.⁵⁴ These factors should be considered as part of better communications.

In the product development process and business development process, the project itself should be organized as a multidisciplinary team which will improve interfunctional linkages. It gives the team a multiple effect of different functions to plan an effective strategy. The personnel transfer for this linkage is shown as a solid arrow in Figure 24. In addition to the team, the field into which the project is settled also is important. This is discussed in 6.3 Institutional Factors.

A special intermediate organization like TMD at XEROX PARC is another way to facilitate interfunctional linkages. TMD continually scans Xerox's internal technology and the market, to determine the best match between them. If the intermediary is able to understand both the technology or market, it will work effectively. However, if it has

⁵² Roberts, E.B. and Fusfeld, A.R., "Critical Functions: Needed Roles in the Innovation Process," *Managing Professionals in Innovative Organizations, A Collection of Readings* Edited by Ralph Katz, New York: HarperBusiness, 1988, pp.101-120.

⁵³ Allen, T.J., *Managing the Flow of Technology*, Cambridge, MA: MIT Press, 1993, pp.141-181.

⁵⁴ Ellis, C., Corporate V.P., Intel Corp., Seminar for Management of Technology Program, Nov.3, 1994.

insufficient understanding of the technology or market, the intermediary sometimes disturbs R&D and marketing activities and increases their paperwork. Therefore, this function does not included in the models in Figures 22 - 25. For highly specialized jobs like developing an alliance, however, specialists like TMD are necessary as intermediators.

6.3 Institutional Factors for Better Process Management

To better manage the development processes just described, especially to bring about better interfunctional linkages, some rules and systems that facilitate development activities are necessary. This subject primarily related to the personnel management systems.

Jobs within projects change along with the development process in terms of quality and quantity. For example, routine work like reliability checks increase in the commercial development stage, while work in the technological problem-solving stage can be published as an academic paper. The schedule becomes tighter as the project progresses. Output from the project members shifts from papers and patents based on an invention to specifications of products. Therefore, these different outputs in a different environment cannot be evaluated by the same measures; different measures of personnel evaluation are necessary for each stage.

In NTT's experience, all the processes were done under a single organization and a single management system. Even if the project had a clear mission of business development, doing routine work next to the research group affected the members' motivation. Moreover, management had difficulty evaluating both project members and other researchers using the same criteria.

To avoid this problem, the project should be moved to a different organization sometime in the product development process, or at least before the business development process.

Figure 26 shows a technology development system at Sharp Corporation.⁵⁵ Sharp started its "Gold Badge Project" system in 1977 to increase development speed and to enhance the effective transfer and integration of technologies among manufacturing groups.⁵⁶ Projects are selected in a Corporate Technical Strategy Meeting. Once selected, Gold Badge projects are separated from the existing laboratories and go under the direct control of executive directors. This system is not an organization, but gives recognition to the differentiation of these projects to the employees. Freed from the existing organization and its rules, the project gains flexibility and can facilitate its development activities. Usually, the new position of the project is closer to the market than to R&D. With this separation, the project can have a wider communication path to the downward market and a clearly defined mission. Most importantly, management gains additional flexibility. Both XEROX PARC and Raychem's R&D have hired a marketing person within their own laboratories. This may be natural in the U.S., but it is not common in Japan. However, the additional flexibility in management makes the employment of marketing person for R&D group possible even in a large Japanese company. Raychem's incubator is such a new organization for their product development projects. To maintain management's flexibility, different systems and organizations from the existing ones are desirable.

Another system necessary for NTT to develop is a dedicated marketing function. Discussions up to now have been done based on an assumption of a marketing function's existence. Here, "marketing" is defined as the identification and satisfaction of customer needs.⁵⁷ In the

⁵⁵ Collis, D.J. and Noda, T., *Sharp Corporation: Technology Strategy*, Harvard Business School case 9-793-064, 1994.

⁵⁶ Nikkei BP, *Nikkei Business*, June 6 1994, p.16.

⁵⁷ Bund, B.E., Senior Lecturer, MIT Sloan School of Management, *Class Notes of Marketing Management*, Sept. 7 1994.

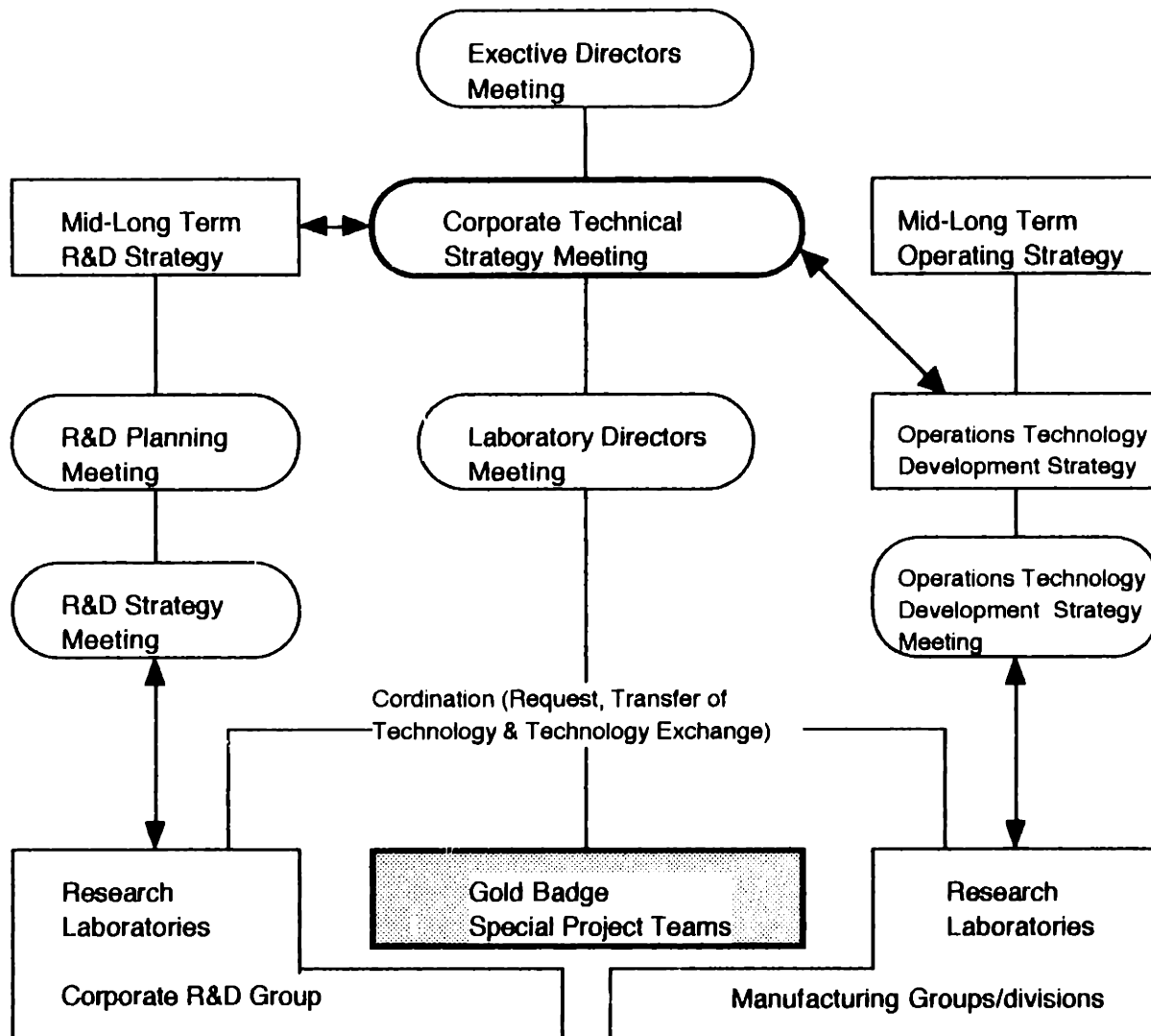


Figure 26 Gold Badge Project System in Sharp
 (Collis, D.J. and Noda, T., 1994)

case of high-technology based products, the customers may not be able to articulate their needs. Therefore, strategic analysis of their potential needs becomes more important. However, this marketing function is dispersed into many departments in the case of NTT, as described in Chapter 4.2.4. This situation is very common in Japanese companies and does have some advantages. All members from top to bottom have some awareness and responsibility in marketing activities, and this total responsibility works well for relatively clear needs. However, a more organized approach is required for the strategic analysis of future, unclear needs. Two possibilities can be considered for building a marketing function into the organization. One is to build an organic network between existing relevant sections which are shown in Figure 9. The other is to establish an independent department of marketing as in many U.S. firms. There is no systematic data and survey for this discussion. However, the organic network approach could maintain the present benefits of total marketing responsibility and therefore be a desirable way.

6.4 General Discussion and Conclusion

This study has examined the R&D-based corporate venturing process in detail. Through a review of NTT's experience of venturing, organizational and management problems were first identified. The management strategies of three U.S. firms-Xerox PARC, Raychem Corporation, and AT&T Bell Labs-were analyzed, drawing on data from interviews and published sources. From the comparison between management at NTT and these three firms, desirable attributes of a venturing process and its management were discussed. From this discussion, I proposed a comprehensive development process model for technologies, products and businesses (Figure 22-25).

The model represents common ground to an end, and admittedly the real development process may be different for different cases. However, the necessary management function and environment for each stage throughout the process could be clarified by the examining this comprehensive process model. I especially focused on the necessity of interfunctional linkages between the technology side and marketing side in each stage. Not only a linkage as a general idea, but also a concrete approach to this linkage, suitable for each process stage was examined. The four modes of interaction are:

- 1) information exchange,
- 2) collaboration within a multidisciplinary team,
- 3) personnel linkages, and
- 4) intermediation by experts or special organizations.

In the early stage of the development process, information exchange is effective. However, team work and personnel linkage become more effective in the latter stages of the process.

To realize this linkage effectively, some institutional problems must be addressed. Most important is the need for a flexible personnel system to realize the personnel links between the technology side and marketing side. If a key person's transfer between R&D and marketing or business units is possible regardless of their rank and post, more strategic linkages can be built between R&D and marketing. This is also necessary for organizing an effective multidisciplinary team. Only through such experiences, can multilingual market gatekeepers be groomed. The other factor is a new organization for the project. From some stage of the product development process, the project should move from the existing organization to the special organization to maximize management flexibility. Freed from the existing organization and its rules, the project members can facilitate their development activities.

APPENDIX A

Interview Questionnaire

These questions were prepared as a guide for discussions about the following aspects of technology-based new business development, especially their marketing efforts:

- a) strategy
- b) management
- c) institutional factors
- d) technology/product development

A. Strategy

1. In your R&D, which is major in terms of resources: "Technology Push R&D" or "Market Pull R&D"? Give some examples of each.
Which has the higher probability of success?
2. Are there any differences between the management for "technology push R&D" and the management for "market pull R&D"?
3. In relation to your main business and accumulated technology, does your new technology and business development tend to be:
 - upstream vertical integration
 - downstream vertical integration
 - horizontal expansion
 - unrelated diversification
4. Has your organization structure changed in the last ten years?
How has it changed?
What is the relationship between this change and corporate strategy?

How did this change work for technology innovation?
Was it effective?

B. Management

5. I have assumed that one key factor of successful technology development, product development, and business development is the interaction between the technology side and market side throughout the development process.

What do you think about this interaction?

When and how do you get market information?

How do you use it in your R&D?

6. How is your functional division (business unit) involved in the R&D strategy and management?

7. Larger companies may have a solid framework of management, but it may sometimes work as an obstacle to flexibility, which is a basic requirement for venturing. How do you balance flexibility and control at the same time?

8. How are technology and products transferred from corporate R&D to divisional development? Is a human bridge or transfer included in the technology transfer?

9. How do you create a venturesome climate?

C. Institutional factors

10. Do you have a reward system for important projects like new business development?

11. How do you evaluate the effectiveness of your R&D?

D. Technology/Product development

12. In the cases of new technology and new products, you sometimes have to ask for trial manufacturing from an outside source because your firm may not have the manufacturing base because of the products newness. If it is a clearly promising product, many subcontractors are willing to make it. On the other hand, it is often very difficult to show them its promising future during the early stages of its development.

In that case, how do you find a subcontractor?

How do you realize trial manufacturing of your new products?

13. Could you tell me the technology background of your R&D people?

What was the distribution in the 1980s? How has it changed?

If you need new technology,

Do you hire new people?

Do you educate your present employees?

APPENDIX B

Firm and Interviewee Information

Dates : February 14, February 17, 1995

Places : Xerox Palo Alto Research Center
3333 Coyote Hill Road, Palo Alto, CA 94304

Raychem Corporation
300 Constitution Drive, Menlo Park, CA 94025-
1164

WorldPartners Company
535 Mountain Avenue, Murray Hill, NJ 07974

Interviewees:

Xerox Palo Alto Research Center

Bob Sprague	Associate Center Manager of PARC
Tom Paoli	Manager, Technology Initiatives Electronic Materials Laboratory
Len Fennell	Manager Electronic Imaging Laboratory
Mark Weiser	Manager Principal Scientist Computer Science Laboratory
Bettie Steiger	Principal Technology & Market Development
Dave Robson	Quality Officer

Raychem Corporation

Joseph G.Wirth	Senior Vice President and Chief Technical Officer
Keith Melton	Director, Technology Planning

Kenneth C.Frederick Director, Business Development
Dennis A.Caponigro Strategic Business Manager
Stephen Moore Section Technical Director
John A.Midgley Vice President, U.S. Corporate Technology
Hundi Kamath General Manager, Raychem Display Products

WorldPartners Company

Paul J.Frankel Vice President

MIT Sloan School of Management

Mary Sonnack Division Quality Associate
 3M Commercial Office Supply Division
 (MIT Visiting Scholar)

Nancy Staudenmayer Doctoral Candidate

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