Commercializing Discontinuous Innovations: Bridging the Gap From Discontinuous Innovation Project to Operations

Mark P. Rice, Richard Leifer, and Gina Colarelli O'Connor

***Abstract*—Since 1995, a multidisciplinary team of researchers has deployed case study methodology to follow the progress of 12 discontinuous innovation projects in ten large R&D-intensive firms. The study has illuminated the challenges of managing the surprisingly difficult transition from R&D project to an operating unit in the eight of the 12 projects that reached transition. A substantial "readiness gap" existed between the project teams and the receiving business units. The challenges have been captured in the form of ten critical questions that must be addressed before a project can be successfully transitioned. Based on an analysis of transition practices, the authors identify seven propositions for improving the effectiveness of transition management suggesting the potential usefulness of the following managerial approaches: 1) conducting a transition readiness assessment; 2) assembling a transition team; 3) establishing an oversight board; 4) developing a transition plan; 5) providing transition funding from corporate sources; 6) laying the groundwork for a big market; and 7) engaging senior management champions.**

***Index Terms*—Breakthrough innovation, discontinuous innovation, innovation, project management, radical innovation, transition management.**

I. Introduction

DURING the 1980s, U.S. and European firms were competitively challenged by Asian firms in many industries, e.g., memory chips, office and factory automation, consumer electronics, and auto making [17]. In response, U.S. firms increased their competencies in managing the development of incremental innovation in existing products and processes, with an emphasis on cost competitiveness and quality improvements [1], [14]. Extensive study of incremental innovation by both business managers and academics led to a variety of prescriptions, including quality function deployment, concurrent engineering, reduced cycle time, just-in-time inventory management, and stage gate product development control systems. These prescriptions have been widely adopted and have helped many American companies regain their competitive positions in the world marketplace.

The attention of managers to incremental innovation, however, came at a price. It diminished the focus and capacity of many companies to engage in truly discontinuous innovation. The negative consequences of too much attention to incremental innovation have been recognized by many business scholars, e.g., J. Utterback [24] and C. Christensen [5], who have noted how firms that dominate one generation of technology often fail to maintain leadership in the next.

Leaders of established companies have acknowledged that discontinuous innovation is critical to their long-term growth and renewal. The Industrial Research Institute, a professional association of the senior technology managers of large established companies committed to R&D, conducts an annual survey of its members. In 2001 "accelerating innovation" was rated the top challenge facing technology leaders, and in 2000 the top challenge was "managing R&D for business growth" [10], [11]. Indeed, the relationship between business growth and innovation is widely understood by executives today, thanks in part to the writing of a number of consultants and business scholars [5], [8], [24]. Discontinuous innovation transforms the relationship between customers and suppliers, restructures marketplace economics, displaces current products, and often creates entirely new product categories.

In an earlier paper, we discussed in detail the kinds of uncertainties and discontinuities that characterize the discontinuous innovation lifecycle [19]. If unresolved, these can delay or stop the movement of the technology toward the market. In initial interviews, our respondents indicated their belief that progress could be assessed in terms of reduction of uncertainty and success in bridging project discontinuities. Even though progress might be uneven, the achievement of project maturity, i.e., readiness for transition to operations, would be marked by elimination of most or all uncertainties. Our respondents assumed that—once the project was sufficiently mature—the receiving operating unit would be able to employ tried and true project management techniques, such as the well-recognized stage-gate system [4], and complete the transition.

Contrary to expectations, this was not the case. By tracking projects in our study through their transition phase, we identified a set of transition activities—required to complete the resolution of uncertainties—that neither innovation teams nor program managers in operating units were prepared to handle. Given the lack of preparedness for recognizing and managing, these remaining uncertainties set against the pressure to stop investing in development and quickly begin generating revenues from operations, and the transition turned out—unexpectedly—to be a final discontinuity in the discontinuous innovation project lifecycle. The intent of this paper is to illuminate the challenges that discontinuous innovation

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The authors are with the F. W. Olin Graduate School of Business, Babson College, Babson Park, MA 02457 USA (e-mail: mrice@babson.edu).

R. Leifer and G. C. O'Connor are with the Lally School of Management and Technology, Rensselaer Polytechnic Institute, Troy, NY 12180 USA.

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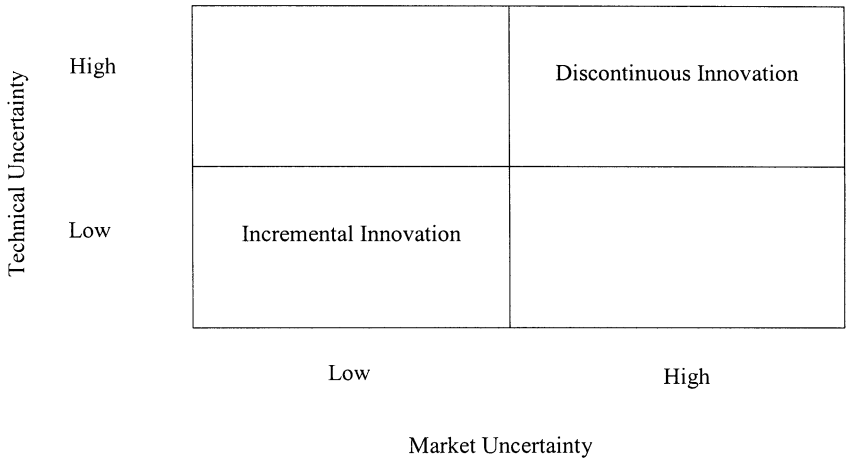

Fig. 1. Project uncertainties: discontinuous versus incremental innovation.

projects experience during transition to operations and to define propositions related to improving the effectiveness of managing the transition process.

II. Literature Review

Souder *et al.* [23], and Lynn and Akgun [14], among others, have focused on technical and market uncertainty to define the spectrum of innovation, as indicated in Fig. 1. The traditional domain of discontinuous innovation is marked by high technical and market uncertainty, whereas incremental innovations typically are placed in the cell where technical and market uncertainty are relatively low.

Technical uncertainties include the completeness and correctness of the underlying scientific knowledge, the extent to which the technical specifications of the product can be implemented, the reliability of the manufacturing processes, maintainability, and so forth. Market uncertainties include the degree to which customer needs and wants are clear and well understood, the extent to which conventional forms of interaction between the customer and the product can be used, the appropriateness of conventional methods of sales and distribution, and the project team's understanding of the relationship of the discontinuous innovation to competitors' products. Discontinuous innovation projects involve high levels of both categories of uncertainty.

As we delved into the longitudinal data on our projects, we discovered that the traditional 2×2 matrix based on technical and market uncertainty was inadequate for capturing the complex, dynamic, and shifting mosaic of uncertainties we observed. The project teams not only had to contend with *technical* and *market* uncertainty, but also with two other categories of uncertainty: *organizational* and *resource* uncertainty. These two additional categories of uncertainty have been recognized in the innovation literature. The uncertainties related to organizational context stemmed from a fundamental conflict between the mainstream organization and the unit engaged in radical innovation, and the difficulty of managing the relationship between them [3], [5], [6], [13]. Engaging in resource acquisition was also an ongoing source of uncertainty for discontinuous innovation project teams [6].

In an earlier paper [19], we observed that discontinuous innovation teams often failed to recognize and anticipate organizational and resource uncertainties. Approaches to organizational and resource issues related to discontinuous innovation projects were markedly different from familiar, standard approaches implemented in continuous improvement (or incremental innovation) product development projects. Failure to recognize and address organizational and resource uncertainties triggered project discontinuities or resulted in slow or inadequate responses to discontinuities, resulting in jolts that diminished corporate support for the projects. These jolts diminish the likelihood of project survival and success [25].

In our identification of the challenges associated with managing the transition from project to operations, we started from the uncertainty framework embodying the four categories of uncertainty: technical, market, organizational, and resource. In our view, a comprehensive understanding of the uncertainty framework presented in this paper will allow project teams to develop a systematic approach to identifying and responding to managerial challenges associated with transition, both those that are apparent at the start of transition and those that emerge as the project team moves through the transition process.

III. Research Design

A. Multiple Comparison Case Study Methodology

The research reported in this paper is part of a six-year (1995–2000) prospective study of management practices employed in large firms in the development and commercialization of discontinuous innovations. The research project employs a multiple case study methodology. Case study research involves the examination of a phenomenon in its natural setting. The case study method is especially appropriate for research in new topic areas, with a focus on "how" or "why" questions concerning a contemporary set of events [7]. The research design can involve single or multiple cases. Multiple cases are generally regarded as more robust, providing the observation and analysis of a phenomenon in several settings. Case study research that employs multiple cases should follow a replication logic [26]. The complexity of case study research

Participating Firm	Discontinuous Innovation
Air Products	Oxygen Separation Technology
Analog Devices	MEMS Accelerometer Chip
DuPont	Electronic Display Material
DuPont	Biodegradable Polymer
General Electric	Digital Imaging Device
General Motors	Hybrid Electric Vehicle
IBM	SiGe Chip
IBM	High Resolution Display
Nortel Networks	Internet Software Rental Technology
United Technologies (Otis Elevator)	Bi-Directional Elevator
Polaroid	Memory Storage Device
Texas Instruments	Digital Micro Mirror Display Device

Fig. 2. Participating firms and their innovations.

and the high level of interpretation that is necessary create an advantage for the use of research teams. Multiple investigators can bring a variety of experience and complementary insights to the research. A mix of different perspectives can increase the likelihood of discovering novel insights. Convergence of opinions from various researchers can enhance confidence in the findings and conflicting views can keep the research from premature closure (see [7]).

Our multidisciplinary research team consisted of seven faculty and several Ph.D. students representing organizational behavior, R&D management, marketing, operations and manufacturing management, engineering, industrial design, strategy, and entrepreneurship. This research team composition is designed to provide a cross-disciplinary interactive examination of the process of discontinuous innovation.

B. Field Study Sample Selection

The firms participating in this study were members of the Industrial Research Institute (IRI), a professional association of the senior R&D/technology managers of Fortune 500 companies. The participating firms and their innovations are listed in Fig. 2.

The projects, selected by the nominating R&D manager, met one or more of the following criteria established through extensive discussion among the members of the research team and IRI:

- new to the world performance features (i.e., fundamentally a new product or service);
- five- to ten-fold (or greater) improvement in known performance features;
- 30% to 50% (or greater) reduction in cost.

The project had to be formally established, with personnel assigned to the project team and with a budget. We gathered contextual information at the firm level, but the project was the unit of analysis. Although the relatively maturity of the projects in our sample varied, all were far from commercialization at the beginning of our longitudinal study.

C. Field Study Data Collection

Each company hosted a minimum of two site visits and granted access to senior managers, project mangers, and project team members, who provided both historic and current information and insights to address the research questions developed by the research team. Interviewees were not randomly selected, but rather were identified by our company liaison to ensure the breadth and depth of knowledge necessary to address our questions and to provide a diversity of perspectives about the development process. Using multiple interviewees reduces the risk of a biased perspective that can arise if only a single individual is interviewed and permits a more complete picture of each project [7], [26].

Data collection occurred in three phases. In Phase I, initial interviews were typically conducted on site with one or two members of the project team, e.g., the R&D manager and/or the project manager. Our team conveyed the nature of the research effort, and the company representatives conveyed the nature of the project, with a mutual objective of ensuring that the project met our criteria. An oral history of the project's origins and chronology to date was collected. The Phase I interviews were taped and transcribed to provide a basis for preparation for Phase II.

In Phase II, a significant subset of the members of our research team (ranging from three to eight members of the team) conducted an all-day site visit at each company. Through consultation with our company liaison prior to the site visit, we developed a list of interviewees who were best suited to address our research questions and arranged an interview schedule. Each company representative participated in multiple interviews with several subgroups of the total research team.

In Phase III, we conducted follow-up interviews via conference call connecting each discontinuous innovation project team and our research team. The interview protocol developed and used for Phase III, through which the insights offered in this paper were uncovered, is provided in Appendix 1. Again all interviews were taped and transcribed. Thus, the data is primarily prospective in nature, to guard against the retroactive rationalization that challenges the qualitative research process.

D. Data Analysis

Qualitative analysis requires a different approach from quantitative analysis because the data is mainly textual and descriptive. To uncover and examine key variables and/or patterns of behavior arising from our data, we used the approach outlined by Yin [26]. The cross case or multicase method enables an understanding of the phenomena beyond each individual firm context and increases generalizability.

In our review of the transcripts, segments that related to the research questions addressed in this paper were highlighted and collected on summary sheets for each project by multiple project members. The summary sheets were then compared and aggregated, and observations were expressed and discussed by all authors, to identify commonalities and dissimilarities. Observations and emerging themes expressed as uncertainties were cross checked with other researchers on our team. Our observations related to the four categories of uncertainties are captured in tabular format. Because of the lack of a frame of reference that would allow our respondents to assess degree of difficulty associated with addressing particular types of uncertainty, our observations are represented as a binary (yes/no) variable.

IV. Discussion of Results

In an ideal world (at least from the perspective of the personnel in the receiving operating unit) the discontinuous innovation project team would hand over a fully specified, tested and ready-to-manufacture product, with a manufacturing line ready to go, and a set of customers ready and willing to order the innovative new product. This would allow the operating unit to ramp up manufacturing and sell to proven customers, thereby significantly increasing its revenues and maintaining or even improving profitability. For the project team, this orientation translates into the need to not only resolve technical uncertainties—with which they are familiar as R&D scientists—but also the need to resolve market uncertainties, find a customer base, and demonstrate market acceptance in order for the operating unit to accept the project. This latter expectation takes the project team into unfamiliar territory. Generally, project teams would prefer that operating unit personnel take on this work, allowing them to move on to another technically challenging project.

However, new products based on a discontinuous innovation are often sufficiently different from current products that potential customers need to be conditioned to the potential of the innovation. Technical specifications that were adequate for the prototype stage require substantial revisions as the new product is finalized for specific applications. In addition, manufacturing ramp up is challenging when the process for producing these new products differs from current manufacturing processes.

Organizational and resource issues also present problems during transition. Partners who were significant contributors during development may come up short during the final phase. In some cases there is uncertainty about where the project will find its ultimate home [2]. We also observed that the receiving operating unit is reluctant to divert resources to completing technical and market development of a discontinuous innovation, given the uncertainty regarding timing and magnitude of the eventual revenue stream. Likewise, R&D is not prepared to cover the business development costs associated with the transition. Hence, there is continuing uncertainty about sources of project funding.

Based on our observations, we identified technical, market, organizational, and resource uncertainties related to managing the transition process, which we captured in the form of ten questions, listed below. We note that seven of the ten questions related to managing the transition include organizational and resource dimensions.

1) Are technical specifications set and manufacturing issues resolved? (technical uncertainty)
2) Do expectations about market development match reality? (market uncertainty)
3) How will applications and markets unfold? (market uncertainty)
4) How do manufacturing challenges impact market entry objectives? (market and organizational uncertainty)
5) How should the business model be finalized? (market and organizational uncertainty)
6) What is the right operating home for the discontinuous innovation? (organizational uncertainty)
7) How should the expectations of the receiving operating unit related to the transition be addressed? (organizational uncertainty)
8) How can the organization structure/process gap between the project team and the receiving operating unit be bridged? (organizational uncertainty)
9) Who should be assigned to participate in transitioning the project to operations? (organizational uncertainty)
10) How can funding be sustained during the transition? (resource uncertainty)

These questions were generated through review by the authors of the interview transcripts related to the interview protocol provided in Appendix I. The review was focused on the managerial challenges associated with the transition process—reported by our respondents—which in turn was used to create the list of ten questions that should be addressed as part of transition management. We then utilized the tabular format in Fig. 3 to reach consensus about whether each project confronted one or more of the uncertainties associated with each of the ten questions. The figure also records the frequency of yes responses—both with respect to each question and with respect to each project.

Regarding question 6, three of the eight projects listed in the table were not transferred into existing business units, but instead formed new or spinout organizations. Among the five cases for which the project was transferred into an existing business unit, in only two cases was there uncertainty about which business unit would receive the project during transition. For all other questions, the majority of the projects confronted one or more issues related to that particular question. In addition, we note that all eight projects that reached transition experienced uncertainties associated with a majority of the ten questions. Hence, we conclude that with the exception of question 6, these questions have broad applicability. Below, we use our general

Project Number (corresponds to Figure 2)

Question Number	1	2	3	4	5	7	9	12	Freq of Yes
1	Y	Y	Y	Y	Y	N	N	N	5/8
2	Y	Y	Y	Y	Y	Y	Y	Y	8/8
3	Y	Y	Y	Y	N	Y	Y	Y	7/8
4	Y	Y	Y	N	Y	N	N	Y	5/8
5	Y	Y	Y	Y	Y	Y	Y	Y	8/8
6	N	N	N	Y	N	Y	N	N	2/8
7	Y	N	Y	Y	Y	Y	N	N	5/8
8	N	Y	N	Y	Y	Y	Y	Y	6/8
9	N	Y	Y	Y	N	Y	Y	Y	6/8
10	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Freq of Yes	7/10	8/10	8/10	9/10	7/10	8/10	6/10	7/10	

Fig. 3. Occurrence and frequency of residual uncertainties during transition.

observations and specific case data to illuminate the nature of the uncertainties embodied in each of the ten transition management questions.

Transition Question 1: Are technical specifications set and manufacturing issues resolved?

Identifying prospective customers willing to pay for the new product or service based on the discontinuous innovation provides an impetus for the transition. During transition, technical development often restarts or is redirected as a result of new learning from initial market entry and as the product is customized for specific application. Early adopters are often willing to accept a prototype and work with the innovating firm to define the form and function of the new product. However, during transition to operations—when the commercialization effort moves beyond early adopters and engages customers who believe they are buying a commercial product—these new commercial customers expect technical development to be fully completed. In the DuPont biodegradable polymer case, the marketing campaign funded through corporate resources uncovered extensive interest among potential customers. New applications emerged that required reformulation of the material and the development of new manufacturing processes.

Likewise, manufacturing issues in prototyping are very different from those that determine the success of ramp up. In the GE digital x-ray case discussed earlier, manufacturing of prototypes was focused on getting a "klugey" but functional system into use by early adopters. As in many other cases, we saw the completion of the transition process delayed because of unforeseen complications in resolving technical uncertainties related to achieving yields for the display technologies used in the new imaging system.

Transition Question 2: Do expectations about market development match reality?

In discontinuous projects, the time and financial investment for market development are underestimated. Indeed, we found that project teams understood the necessity for dedicating time and effort to deal with technical uncertainty in discontinuous innovation. However, they were less aware of and prepared for the efforts required for market development. Because a product based on a discontinuous innovation represents a significant departure from current products, customers are naturally wary. They may be uncertain about reliability, getting locked into a proprietary technology, and/or the commitment of the innovating firm to provide customer support and to stay the course with the new product. Inevitably the sales and marketing process for a new product based on a discontinuous innovation is more complex and time consuming than would be typical for an incremental innovation. It requires application development, customer education, and user training.

Initial assumptions about target customers can prove false. By educating lead users about the technology and probing potential applications, the project team learns from and about the market [20]. The project team developing Nortel Networks' internet software rental technology applied the learning from its false start to redirect its marketing efforts toward more promising potential customers. However, this delayed the financing it was seeking and therefore lengthened the transition period.

Transition Question 3: How will applications and markets unfold?

The process of market development is one in which the firm not only learns about the market, but it helps the market learn about and understand the technology and its possibilities. Everyone would like to find a "killer application" capable of dominating a mass market. But these kinds of applications often do not emerge in the early commercialization period of discontinuous innovations [12]. Probing and learning [15] continues through transition and even after the operating unit is up and running with new products. To encourage market development, several project teams we studied moved to a strategy of early niche entry applications. IBM's silicon germanium chip project was transitioned to the operating unit on the strength of initial customer enthusiasm within a set of identified applications. But a year later it was still in the "project stage" within the operating unit, which continued to explore and develop market entry applications. The original killer market had not materialized as quickly as the project champion had expected.

A similar situation occurred in that transition phase for Texas Instruments' digital light processor project. After a number of application false starts, TI came to market with big screen projection systems for home entertainment centers. The $10 000 price tag made it unlikely that this would be a mass market application. However, TI was confident that it would be able to

grow the market based on this and several other applications with modest market potential. Likewise, DuPont's biodegradable polymer project found no killer application in the early years of commercialization. Placing ads in technical journals and trade magazines was one method that DuPont used to learn about potential niche applications. That exercise resulted in the identification of over 30 potential applications. During transition, the product manager in the business unit targeted the four that seemed most promising.

Discontinuous innovations often undergo "application migration," a term used to describe the cycle in which the firm learns about the market, chooses an initial entry application, and continues to learn. Simultaneously, early adopters and lead users in other market domains become aware of the innovation and inquire about adapting it for different uses. This proliferation of application prospects allows the team to migrate toward the most promising early market opportunities, as happened in the DuPont case, and may eventually lead to the discovery of the killer application that is not initially obvious. Even in the GE digital x-ray project, for which the overarching application was clearly medical imaging, initial target applications emerged through market learning—and were not those originally anticipated to be primary targets.

In fact, some discontinuous innovations have become major commercial successes even though no major customers or mass-market applications were identified initially [9], [11], [16]. Success in these cases resulted from serving many smaller markets from a technological platform adapted to multiple applications.

Transition Question 4: How do manufacturing challenges impact market entry objectives?

Manufacturing strategies may also influence the development of market entry strategy. In the TI case, for example, the need to reduce manufacturing yield problems required that the entry strategy focus on high-margin applications first, leaving mass market applications until later. In other cases, firms focused on large mass market applications to impose a dominant standard early on in the game, and paid the price in short term financial performance. Analog Devices, for example, took orders and promised deliveries of its air bag actuators, the first product to be introduced based on its accelerometer chip, before its accelerometer manufacturing process provided reasonable yields. In the first several years of operation, the new operating unit was losing money but was gaining market recognition and growing sales. Its objective was to set a new standard for the industry, allowing the market to learn about the technology.

Transition Question 5: How should the business model be finalized?

In our case studies, market development activities stimulated the market's evolving understanding of the innovation. Hence, the business model could not remain static. Those responsible for accomplishing the transition continued to develop and refine it as the market evolved and as learning accumulated.

In some cases, the firm provided the market with a more complete product than had been originally defined in the business model. The objective was to help the market begin to use it quickly [16]. Texas Instrument's early decision to provide the entire display engine (the DMD chip, the lens, the housing, the power source) was not directed at capturing more of the value chain. Because TI determined that its target customers were not prepared to build the chip into their own devices, the company decided to provide the entire display engine in order to accelerate adoption of the innovation. Once several applications were well established, TI unbundled its innovation and provided the core technology only to customers with superior capabilities for delivering other parts of the value chain. Suppliers of lenses, housings, and power sources emerged, and new applications demanded different specifications for those parts anyway. This resulted in a shift away from the initial business model.

Transition Question 6: What is the right operating home for the discontinuous innovation?

Selecting the appropriate location for the new operating business is a critical decision. In the eight projects that reached transition, we observed three options with respect to the receiving operating unit: existing business unit, new business unit and spinoff.

Transition to an existing business unit. If the firm chooses to develop the new business internally, the most straightforward transition is to an existing business unit. However, because of the costs and risks associated with these startup operations, often the discontinuous innovation project is transferred into an existing business unit, even if it requires a "force fit" against resistance from the business unit. The issue is typically a misfit between the needs of the discontinuous innovation project and the business unit's current capabilities in manufacturing, sales and marketing, and distribution. The greater the misfit, the greater the investment required for retraining personnel and modifying the business unit's operating systems. Unless there is a corporate commitment to support this process, with financial resources and an adjustment in performance metrics, there will likely be resistance from the business unit.

Force fitting a project into an existing SBU can have fatal consequences, as the existing SBU will either fail to give it full support or will attempt to drive it through its inappropriate systems of distribution, financing, and performance review [2]. In one of our case studies, the new business development manager received the go-ahead from corporate management to initiate the handoff to a business unit. When he contacted the head of the business unit, she asked where he had manufactured the prototypes. She was surprised to find out that the prototypes had been manufactured on her production line. Failure to identify the receiving business unit earlier and to coordinate with that manager caused substantial delays in the transition process for this project.

Establishing a new business unit to receive the project. When the innovation is divergent from the firm's existing strategic framework, the innovation is an *unrelated diversification* [22]. This situation is exemplified by Polaroid's development of a memory storage technology, an innovation that was far outside the corporation's strategic boundaries. Polaroid's vision was to transform the product structure of the company; hence, they established a new business unit and developed a strategic partnership with another firm that was, and continues to be, a leader in that market space.

Establishing a spinoff organization to receive the project. If the fit is poor and if the firm is unwilling to leverage the innovation to stretch its competency base, then the business will

most likely be spun off [21], as occurred in the NetActive spinoff from Nortel Networks. In this situation, the parent firm must determine its relationship with the spinout firm. Are there competitive issues related to access to technology? Will the spin out firm be a key supplier? How can the parent company maximize the return on its investment in the discovery and development of the discontinuous innovation? This is important not only with respect to financial returns but also because of the impact—positive or negative—on the firm's efforts to extend its technical capabilities and market experience.

Transition Question 7: How should the expectations of the receiving operating unit related to the transition be addressed?

Applications are uncovered during a period of discovery in which the innovative firm educates the market even as the market educates the firm about possible applications. Tensions are heightened, however, when early promises of big markets are not delivered immediately. Operating units are under pressure to create sales volume and ramp up market share as quickly as possible after new products are introduced [5], [21]. Entry strategies are typically built around maximizing those objectives. Our projects presented a much broader set of objectives; hence, the entry strategy for a discontinuous innovation may be in conflict with the operating unit's expectations. Business unit managers have sales objectives to meet, and the trial and error required to find the right market entry point or to build the business through many small niche applications typically makes rational business unit managers and their product managers uncomfortable. Managing the operating unit's expectations in this regard is critical.

Transition Question 8: How can the organization structure/process gap between the project team and the receiving operating unit be bridged?

According to the chief scientist on GM's hybrid vehicle project, operating business units are not opposed to new ideas, as long as they are new ideas that do not require the operating units to do much that is new. The receiving unit naturally wants the uncertainty and risk reduced to the minimum, so that it can focus on producing and selling the product, growing the market, and generating increasing revenues and profits.

In transition the activity is no longer a discontinuous innovation development project, but it is not yet an up-and-running operating business. Even when some or all of the project team can be transferred into the operating business, and even when the new or established operating business unit is ready to receive the project, the organizational transition is beset with difficulties. In fact, in three of the case studies, the project was transferred to a business unit and subsequently transferred back into R&D. In another case, the responsibility for the project was transferred to a product manager in a business unit but the project continued to engage R&D in transition activies for five years after the transfer. It was clear that the companies in our study all had inadequate organizational structures and processes for driving the transition to completion quickly and efficiently.

Transition Question 9: Who should be assigned to participate in transitioning the project to operations?

Difficulties with people and their expectations during project transition are typical [2]. In seven of the eight projects in our study that made it to transition, key personnel either left the team or were reassigned. The mismatch between the skills and interests of the champion and the needs of the project as it moves through the transition creates a human resource challenge. At Analog Devices, the discontinuous project champion was not willing to play the corporate politics required to mainstream the accelerometer project and left the company. Often, individuals who play critical developmental roles in the project team do not have the skills or the sense of commitment required to be effective during the transition.

There is also significant danger of handing off responsibility to a product manager in a business unit whose training, skill, and expectations relate to growing revenues and market share for established product lines. Typically, the manager has responsibility for multiple product lines. Both the product manager and the business unit are accustomed to basing performance evaluation on short-term results. For discontinuous innovations, there is often a significant lag in market development. Hence, in the short term managing the transition activities is a distraction from the other activities that produce the kind of measurable results upon which the product manager is judged.

In one of our case studies the initial transition manager did not dedicate sufficient energy and attention to getting the discontinuous innovation into the market and the project languished. A second manager from the business unit was assigned the transition management task. Progress was still so slow that, in frustration, the director of new business development—who was judged by the results of the projects he transferred to the business units—explored alternative transition management strategies. Eventually the project was transferred back into R&D's new business development organization.

Transition Question 10: How can funding be sustained during the transition?

Operating units were typically reluctant to invest their already stretched resources in getting discontinuous innovations to market. Without sufficient additional investment, ramp-up engineering and development, market development and customer education were not accomplished expeditiously. Late in the discontinuous innovation lifecycle, project teams were often unable to acquire the kinds of external funding, e.g., government R&D funding, that was available during early development. Transition funding typically came from a combination of internal sources (corporate, R&D, new business development organization, and business unit), or from external partners. In the GE digital x-ray case, during transition revenues were rapidly ramping up for the initial application, but development of secondary and tertiary applications continued. As a result, the project continued to receive substantial research funding from government agencies and ramp up support from Central Research and Development, the GE Medical Systems business unit and even from the CEO's discretionary corporate resources.

The specific uncertainties that must be addressed if the transition gap between the discontinuous innovation project and the operating unit is to be successfully bridged are represented schematically in Fig. 4.

Based on the observations captured by the ten questions above, we present seven proposition related to increasing effectiveness in the transition process.

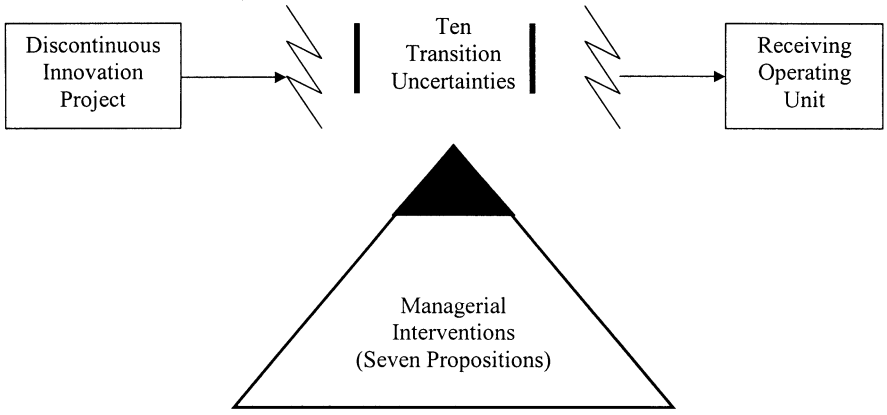

Fig. 4. Model of the transition gap.

V. Seven Propositions for Increasing Effectiveness of Transition Management

All of the questions discussed above reveal that managing the transition from an innovation project to an operating business is neither simple nor easy. Resolving the remaining uncertainties during transition takes longer and requires greater investment than anticipated. However, we propose that by defining a transition as a specific set of activities requiring special skills and resources, companies can accelerate the transition process, reduce the risk of failure, and improve the firm's transition management competency. Below we offer seven propositions for increasing the effectiveness of transition management. We refer to the project team and its home organization as the "sending unit" and the operating unit as the "receiving unit."

Proposition 1: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved through the establishment of a transition team.

Given our observations of the gaps in capabilities—within both project teams and operating units—required for accomplishing the transition, we propose that a transition team, appropriately assembled, will have a higher probability of successfully completing the transition. Our industry partners observed that this recommendation had the effect of creating two transitions in place of one—from project to transition team and from transition team to operating unit. However, there was a willingness to acknowledge that it might be easier to bridge two smaller gaps rather than trying to bridge a single, more daunting gap.

Our observations lead us to suggest that a transition team should include three sets of individuals:

- personnel from the discontinuous innovation project team;
- personnel from the receiving operating unit;
- transition management experts, with experience and training.

Since a successful transition requires that the accumulated learning of the innovation project team be brought to bear, key project team members should either be placed on the transition team or made available to serve as advisors. If the project champion has been effective, he or she should play a key role, as leader if he or she has the right skills. If the project manager does not have the skill set required to manage the transition, senior management needs to manage the leadership succession process carefully. The discontinuous innovation project manager may be reluctant to give up the leadership role, particularly since that individual had been the prime mover in overcoming multiple hurdles to get the project to this point. A key challenge for the firm is retaining the project manager, whose experience is invaluable for the ongoing discontinuous innovation activities of the firm. If the firm manages the succession well, the project manager will be retained *and* the transition team will get the leader it needs.

The operating unit should be as well represented on the transition team as the discontinuous innovation project team. The operating unit personnel will carry the knowledge base derived from the transition experience into the new business. Ideally, the transition team should be headed by a manager with specific transition management skills and capabilities. Finally, people who have knowledge and experience in facilitating transitions should be recruited for the team.

Proposition 2: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved through the establishment of a transition oversight board.

Who should judge the performance of the transition team? Neither the receiving operating unit nor the R&D organization that spawned the project should take on this task. Instead, senior management should create a separate oversight board for each transition effort, which can concentrate the power of senior management supporters. It also provides a natural mechanism for reviewing progress of the transition team and ensuring cooperation of the various stakeholders. As in all other situations, the oversight board will only be effective with the right people, those with the organizational clout to push the transition effort to a rapid and successful conclusion and with the knowledge of the dynamics of the transition process to know what needs to happen.

The performance of the transition team should be measured by standards that are different from those of the operating unit and different from those of the R&D based discontinuous innovation project team. Similarly, the transition team's budget should not be provided by either R&D or by the operating unit. Each of these two constituencies has a stake in the success of the transition, but each has biases and established operating modes that may compromise the effectiveness of the transition team.

The transition team needs to aggressively continue "probe and learn" activities to respond to the need for continuing learning but does not have the luxury of a long time horizon before coming to closure. It will be expected to move into operations mode, and thus must finalize products, business models, and selection of applications in order to establish a foundation for generating operating revenues. The more success it can demonstrate in reaching closure in these decisions, the more likely it will be permitted to explore emerging application opportunities. These provide the foundation for maximizing the firm's ultimate return on investment. Transition management and transition oversight require an intense and demanding balancing act reflecting the need to accelerate to closure while simultaneously pursuing new opportunities.

Proposition 3: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved if the sending and receiving units engage in an assessment of transition readiness.

This involves information sharing and negotiation between the project team and the receiving operating unit. The two sides can determine how much progress the project team will make and how much progress the receiving team will require. With this mutual understanding, the transition tasks can be identified and the resources and competencies required for completing the transition can be defined.

On the one hand, if the project team resolves as many uncertainties as possible and the operating unit develops an effective "early receiving" capacity, then the gap will be minimized. However, to the extent that either side lacks the skills or commitment to transition management, they may engage in activities ineffectively and increase the likelihood that the project will flounder. The outcome of this exercise is likely to be better and more useful—and the process of producing it more efficient—if a third party takes the lead in conducting the assessment, such as personnel who have been trained and are experienced in transition management.

The results of a three-year collaboration between the authors and a committee of the Industrial Research Institute aimed at developing a transition readiness assessment instrument and procedure are reported in O'Connor *et al.* [18].

Proposition 4: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved if the transition team develops a detailed transition plan.

The first task of the transition team should be to complete a detailed transition plan. Most of the information for the plan should be available in the project team's knowledge base and from the readiness assessment exercise. This plan should define the tasks, a timetable, roles, and responsibilities of team members.

The transition plan should guide the efforts of the team and provide a yardstick for measuring progress. However, because the nature of transition management is significantly different from traditional project management, we caution against the assumption that tried and true project management practices can be applied. Since the transition will inevitably involve confronting residual uncertainties—some of which will only emerge during the transition—the plan needs to provide slack time and resources and the opportunity to redirect based on learning. Of course, it should also provide for a mechanism to kill the project if progress is limited or unacceptably slow.

Proposition 5: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved if transition funding is committed from corporate resources.

Unwillingness on the part of the receiving business unit to commit sufficient resources needed to realize the innovation's full potential is a major threat to successful transition. In several cases, we observed tension between a parent company's desire to reach breakeven as soon as possible and the desire of its new venture to continue expansion and experimentation with new applications. The parent company risks stunting the growth of the venture by focusing on exploitation of existing applications in order to achieve near-term profitability. Alternatively, it can choose to support the growth of the venture via exploration of new application arenas, with all the accompanying uncertainty. Continuing down the latter path requires continued senior management attention and financial investment to sustain the transition effort. Recognizing this, some companies (e.g., Air Products, DuPont, and GE) have continued to support the activity with R&D funds and/or personnel during the transition. In the digital X-ray case, GE corporate R&D supported the project with 50 people even after the project was officially handed over to the receiving operating unit, GE Medical Systems. And as described earlier, funding continues to be provided out of the discretionary budget of the CEO. Senior management must ensure that corporate funding provided via funding separate from allocations to business units, whether through the R&D unit or from general corporate funds, is available to complete the transition.

Proposition 6: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved if the transition team lays the groundwork for a big market.

The ultimate goal of any project of discontinuous innovation is a "killer" business. From a market development perspective, that goal can be reached along several alternative paths, ranging from pursuit of a killer application to building revenues through many niche applications.

Even where there is a single large potential market—e.g., the telecommunications applications of IBM's silicon germanium technology—it may not be easy to break into it. The best strategy is often the pursuit of many small applications, at least initially. Taking this approach helps educate potential users regarding the potential of the technology and thereby helps lay the groundwork for major new markets.

It is difficult, but critically important, to set realistic expectations about the likely evolution of the market. There will continue to be dead ends and unexpected opportunities, as well as the applications that work out as expected. Unless there is flexibility in the ramp up of the new business, there is a risk the firm will shelve the project rather than continue to invest in the market development activity required to reap the benefits that the innovation offers. Requiring new businesses based on discontinuous innovations to meet high hurdle rates too soon may kill them before they have time to develop and mature.

Proposition 7: The prospects for successfully completing the transfer from the sending to the receiving unit will be improved if senior management champions of the transition effort are identified, recruited, and charged with the responsibility of completing the transition successfully.

The leadership of the firm—senior corporate management, the chief technology officer, the R&D Director, and the receiving business unit managers—need to give the transition process a high priority if it is to be successful. Typically discontinuous innovation projects do not reach the transition phase without a "push" from senior technical managers. The probability of transition success is enhanced if there is also "pull" from the receiving business unit. All the R&D managers we interviewed stressed the importance of having two champions: one within the receiving business unit and another at a high corporate level. As exemplified by the GE case, in which the new head of the medical systems business unit enthusiastically supported digital X-ray project, the transition is most likely to succeed when a champion is found within in the receiving unit. This individual creates business unit pull by articulating the value of the project to the future of the unit. A discontinuous innovation project also needs backing at or near the top of corporate leadership. The authority of the senior sponsor safeguards the project against the intentional or unintentional sources of resistance. Identification of a senior management transition champion is critical for successful transition of a discontinuous innovation project to operations.

VI. Conclusion

At the outset of our study, our respondents indicated that they expected that the multiplicity of uncertainties besetting a discontinuous innovation project would be sufficiently reduced by the time of handoff of the project to the operating unit that the transition could be accomplished with minimal difficulty. However, the reality was much more difficult than initially envisioned. The transitions of all projects were more complicated and took longer than anticipated, for a variety of reasons: difficulties with key external partners, significant changes among project champions, the necessity for much greater follow on investment than expected, restructuring or redirection by corporate or business unit leadership. In fact, in three cases the project was transferred to an operating unit and subsequently was transferred back to the new business development organization within R&D, reverting to the status of discontinuous innovation project. This research effort has uncovered critical issues that must be addressed to successfully and expeditiously complete the transition of a discontinuous innovation project to operating status.

We have offered suggestions—in the form of propositions—for improving the effectiveness of transition management, based on the observation of firms confronting transition challenges. Future research may be directed toward testing the effectiveness of these recommendations and uncovering additional challenges and solutions related to managing the transition.

Appendix
Questions for Follow up Interviews With Companies in the Managing Discontinuous Innovation Project

What has changed since our last discussion?

- What have been the macro changes in your company?
- In your industry?
- In your target market?

Manufacturing:

- Have manufacturing personnel become involved in the project and in what ways?
- Have manufacturing issues come into play and how?

Design:

- Have design personnel become involved in the project and in what ways?
- Have design issues come into play and how?

Evaluation:

- How has the progress of the project been evaluated?
- How have members of the team been evaluated?

Organizational Issues:

- Has the organizational structure of the project changed? If so, how?
- Has the relationship between the project and the company changed? If so, how?
- How has the relationship between the project and the company affected the progress of the project—positively and negatively?

Technical progress:

- Successes and failures?
- How close are you to having a product ready for market?

Market:

- What are the market uncertainties facing you at this point in the project? What questions are you trying to get answered now?
- How are you getting those questions answered? What processes are you using? Which have been successful and which not, and why?
- How close are you to commercialization, on each project?
- What are the issues that you are dealing with now in thinking about commercialization?
- How confident are you that your understanding of the market is clear and correct?
- What new knowledge have you gained about markets for products that will be derived from your innovation(s) associated with this project in the past year?
- Who has been conducting the market related activities and what activities has each been doing?

The team:

- Who has left and who has joined and why?
- What roles are each member of the team playing?

Champions:

- Has the cast of characters changed?
- How has their involvement in the project changed? How have their roles changed?

- What characteristics of your past (and/or new) champions have been important in achieving their impact on the project?

Financing:

- How has the financing of the project been accomplished during the past year?

Decision making:

- What key milestones were reached during the past year?
- How was progress evaluated and decisions made?
- Who was involved in the decision making?
- What new issues have emerged?

Alliances:

- What internal alliances have played an important role in the project? In what ways? Positively and negatively?
- What external alliances have played an important role in the project? In what ways? Positively and negatively?

Final Question: What have we failed to ask that would elicit information that is important for us to have, and what are the answers to those questions?

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Mark P. Rice received the B.S. and M.S. degrees in mechanical engineering and the Ph.D. degree in management from Rensselaer Polytechnic Institute.

He is the Murata Dean of the F. W. Olin Graduate School of Business and the Jeffry A. Timmons Professor of Entrepreneurial Studies at Babson College. He previously served as Director of the nationally recognized RPI Incubator Program and the Severino Center for Technological Entrepreneurship at Rensselaer Polytechnic Institute. He is co-author of *Radical Innovation: How Mature Companies Can Outsmart Upstarts* (Cambridge, MA: Harvard Business School Press, 2000). His research on corporate innovation and entrepreneurship has been published widely, in academic and practitioner journals including *Organization Science*, *R&D Management*, *Journal of Marketing Theory and Practice*, *Academy of Management Executive*, and *California Management Review*. He co-authored (with Dr. J. Matthews) *Growing New Ventures—Creating New Jobs: Principles and Practices of Successful Business Incubation*.

In 2002, Dr. Rice received the Edwin M. and Gloria W. Appel Entrepreneurship in Education Prize. He has been a Director and Chairman of the National Business Incubation Association, which honored him in 1998 with its Founder's Award.

Richard Leifer received the A.B., M.S., and Ph.D. degrees from the University of California at Berkeley and the University of Wisconsin at Madison.

His work experience includes serving as President of his own small business and consulting in various small and large firms. At present he is engaged in understanding how established companies can increase their capabilities for breakthrough innovation. He is a coauthor of *Radical Innovation: How Mature Companies Can Outsmart Upstarts* (Cambridge, MA: HBS Press, 2000). His work has been published in *The Academy of Management Journal*, *Academy of Management Review*, *Academy of Management Executive*, *the Journal of Product Innovation Management*, and the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT. His current research interests include the management components of radical innovation.

Dr. Leifer is a member of the Academy of Management and the Strategic Management Society.

Gina Colarelli O'Connor received the Ph.D. degree in marketing and corporate strategy at New York University, in 1988.

She is an Assistant Professor in the Lally School of Management and Technology, Rensselaer Polytechnic Institute. Her fields of interest include new product development, radical innovation, and strategic marketing management in high technology arenas. Prior receiving the Ph.D. degree, she spent several years with McDonnell Douglas Corporation in contract administration, and at Monsanto Chemical Corporation's Department of Social Responsibility. The majority of her research efforts focus on how firms link advanced technology development to market opportunities. She has had articles published in *The Journal of Product Innovation Management*, *California Management Review*, *Academy of Management Executive*, *The Journal of Strategic Marketing*, *The European Journal of Marketing*, *Psychology and Marketing*, *Business Horizons*, *The Journal of Advertising Research*, *and The Journal of Advertising*, and is one of the authors of the book *Radical Innovation, How Mature Firms Can Outsmart Upstarts* (HBS Press, 2000).