Chapter 4

# Open, Radical Innovation: Toward an Integrated Model in Large Established Firms

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# Introduction: The Problem of Radical Innovation in Large Established Firms

Organizational growth and renewal are fundamental to any firm's long term survival (Jelinek and Schoonhoven 1990, Morone 1993). Firms pursue multiple approaches to renewal. One path is to gain new capabilities via acquisition of or merger with companies that offer technologies or market entrée that the focal firm may lack. Another approach is organic, generative growth, meaning growth through the development of new lines of business based primarily on technical competencies nurtured from within the organization. When the promise of the opportunity is very large, and the concomitant risk and uncertainty of the opportunity are high, the technology and innovation management literature refers to that phenomenon as radical innovation (Leifer et. al. 2000, Morone 1993).

Whether or not large established companies can develop and commercialize radical innovations (RI) is a moot point. The fact is, they need to. Mature firms depend on radical, breakthrough innovation to provide the next platform for growth as mature businesses become commoditized and loyal markets become saturated. But even though big firms rely on breakthroughs, they have not built the supportive infrastructure necessary to enable breakthroughs to be commercialized. Instead, large firms have tended to rely on maverick champions with a connection to a supportive senior management sponsors to push the project through a system that's tuned for incremental innovation (Leifer et. al.2000). Depending on these 'one-off' RI projects to be successful every ten years is not enough to fuel the organizational renewal necessary for the established firm.

While Radical Innovation (RI) is widely viewed as one approach to generative growth available to large, established organizations, the evidence suggests that forces operate within such organizations to impede RI success (Cyert and March 1963, Dougherty 1992, Dougherty and Heller 1994, Gilbert et. al. 1984, Hill and Rothaermel 2003, Leifer et. al. 2000, Teece et. al. 1997). Organizations grow by gaining efficiencies of scale and scope in specific core competency areas that, ultimately, become core rigidities (Leonard-Barton, 1992), or core incompetencies (Doughtery, 1995). They lack patience in terms of converting investment of time and resources into profits due to the pressures of equity markets, yet radical innovation can require more than a decade of investment before financial returns are seen (Gilbert et. al 1984, Quinn 1985). Some scholars believe that, in fact, large established firms are incapable of meeting the demands of current stakeholders and simultaneously being proactive regarding future disruptive technologies (Christensen, 1997).

A host of other scholars argue, however, that organizations are capable of developing appropriate management systems for radical innovation, but are simply underdeveloped in this regard (Ahuja & Lampert, 2001; Hill & Rothaermel, 2003; Jelinek & Schoonhoven, 1990; Leifer et. al. 2000; Morone 1993). Schumpeter's (1950) early observations of the "process of creative destruction" describing the ability of new companies to commercialize radical technology at the expense of incumbent firms, has been validated by many scholars (Rosenbloom and Cusumano 1987, Utterback 1994). The challenge has been for such groups to build their competencies before senior leadership loses patience. It has been documented that most new ventures groups and radical innovation hubs last, on average, 4-5 years (Fast 1978). Just as they're coming up to speed on the appropriate tools and mechanisms to use, they are de-funded due to changes in the organization's growth strategy or because they have not 'delivered enough.' A generation later, they are resurrected, but the learning has dissipated.

Thus large established firms are seeking ways to develop RI competencies that can be sustained over time. The Open Innovation model offers firms an enormous help. If discoveries can be sourced from external parties as well as internal groups, and the innovation required to nurture those discoveries into business opportunities becomes more interactive with market and technology partners sooner, the lifecycle of RI can be substantially shortened. As I reviewed our research program on large established companies' attempts to build radical innovation competencies and infrastructures, I came to understand how companies' innovation programs have incorporated an increased orientation toward Open Innovation, and to observe how it is manifesting itself across the commercialization spectrum. Our participating companies are partnering and leveraging universities and other companies as a way to a) learn quickly and inexpensively, b) develop or co-opt new capabilities that radical innovation spaces require, and c) actually begin to create new markets.

**Defining Radical Innovation and RI Competency**

We define Radical Innovation as the ability for an organization to commercialize products and technologies that have a) high impact on the market in terms of offering wholly new benefits, and b) high impact on the firm in terms of their ability to spawn whole new lines of business. We operationalized these impact levels as projects with the potential to offer either a) new to the world performance features; b) significant (e.g. 5-

10x) improvement in known features, or c) significant (e.g. 30-50%) reduction in cost [1] (Leifer et. al 2000, McDermott and O'Connor 2002). RI's often require the use of advanced technology and can enable applications in markets unfamiliar to the firm (Hage 1980, Meyers and Tucker 1989, Morone 1993). They may result in dramatically modified consumption patterns and business models in existing markets (Dhebar 1995, Kozmetsky 1993, Roberts 1977) or the creation of entirely new markets (Betz 1993, Roberts 1977). All of this is reflected in the high levels of market, technical, resource and organizational uncertainty (Day 1994, Galbraith 1982, Maidique and Zirger 1985, Rice et. al 2002, Utterback 1994) that the project teams experience, which translates into long project maturity durations, unpredictability (Schon 1967) and non-linear project development (Cooper et. al. 2002). Such uncertainty makes conventional project management approaches inappropriate and requires the firm to develop new, situation specific competencies in technology, market, resource management and organizational domains (Vanhaverbeke and Peeters, 2005).

A Radical Innovation Competency, then, is the ability for a firm to commercialize radical innovations repeatedly. The working hypothesis that drove our research program beginning in 1995 was that large established firms had become highly capable at managing incremental innovation using stage-gate like processes, but that the processes and evaluative criteria used to fulfill a stage gate approach, if applied to the high uncertainty regime of radical innovation, would kill potential breakthroughs before they could mature enough to impact the market or the company. Because established companies excel based on high volume based operational efficiencies, the management

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[1] We use the word *potential* because the study's methodological approach was a longitudinal one rather than a case approach of data collection post hoc. We therefore did not know if the projects would be successful when they were first qualified into the study.

system in place is oriented toward efficiency. Stage gate processes align with those objectives, and ensure that firms work in familiar markets and technology domains where they are leveraging current know how and relationships. Radical innovation, almost be definition, stretches firms into new market, technical and business model territory. The result is that the management system that works so well for incremental innovation is mismatched with the requirements of radical innovation.

**The Importance of Open Innovation to RI Competency**

We observed twelve potential radical innovation projects in ten firms from 1995-2000 (Leifer et. al. 2000) and developed timelines for each project to capture the uncertainties, discontinuities and to analyze how the project teams have dealt with them. Figure 1 depicts the chronology of Texas Instruments' development of the Digital Micromirror Device (DMD®). The solid horizontal lines represent applications pursued, the thickness of the lines indicates level of commitment of human and financial resources, and the short vertical lines mark project discontinuities. The figure reflects the long years in the lab "experimenting" with the technology, but the fact is that, once the team had a direction in terms of a potential application to pursue, the project gained momentum. New technical directions were pursued (though not always successfully) and new market partners were engaged. Eventually TI's Digital Imaging business emerged from this effort. It is now part of the Semiconductor Business group. There are four product platforms, and TI commands 70-90% market share in several of those, with new applications continuing to emerge.

One wonders how long that early experimentation work would've gone on if TI had engaged early on in considering the market possibilities, or, in fact, what the benefit was of TI supporting this work fully in house rather than working through a university or other lab to support it. Certainly the timeline of this ultimately extremely successful RI project would not have been 20 years as it is currently depicted.

Similar issues arise in all of the projects we observed. The RI lifecycle is so rife with uncertainty, stochasm, starts and stops, that it is difficult for large established organizations, who thrive on operational excellence, to tolerate them from beginning to end. Given the length of the RI lifecycle, the Open Innovation concept offers great promise for helping enable RI in large established firms. While expectations for its contributions to business growth and profitability are high, management's patience for investing in the scientific discovery and invention are quite thin, as evidenced by the reduction in R&D investment over the past 20 years in US Corporations (O'Connor and Ayers 2005). In addition, while large established firms are highly adept at managing markets that currently exist, their skill sets, operating models, performance measurement systems and organizational structures severely infringe on their ability to create wholly new markets (O'Connor and Rice 2005). Any new conceptual mode of operating that can help speed any part of the process is welcome. The open innovation model does just that by helping companies leverage their vast resources and market power to identify and partner appropriately but also to provide the context for potentially game-changing innovations. As Open Innovation emphasizes, and as our research also concludes, the value from innovation lies more in identifying the context and applying the necessary business resources to commercialize the technology, than in having the initial idea originate in one's own lab.

Most expectations are that start-up organizations are more appropriate as engines of RI (Leifer et. al. 2000). Start ups arise frequently on the basis of a radical invention that holds promise of offering wholly new performance features. In fact, that is the promise that the venture capital community seeks to fund. In addition, start ups do not suffer the organizational bureaucracy of large established firms, and so can be flexible in terms of reading market signals, structuring appropriate business models, and accepting smaller orders initially. We have learned that, in fact, markets for radical innovations emerge in just this manner (Lynn, Morone and Paulson 1996, O'Connor 1998, O'Connor and Rice 2005).

However, start ups face numerous disadvantages in commercializing radical innovations, including a lack of resources. They do not have an identifiable company brand name and therefore lack credibility with partners and the market. In addition, start ups do not have a broad base of knowledge assets to draw upon. They typically lack the complementary assets needed to scale the innovation. Large firms, we have seen, depend heavily on rich, powerful internal networks to answer questions, gain contacts and get technical and market related questions answered (Kelley, Peters and O'Connor 2005).

In the past, large established companies have operated on the assumption that they must develop everything internally to maintain competitive advantage. Open innovation can help alleviate this and enable large companies to contribute in ways that leverage their richest capabilities. What is needed is to understand the balance of open innovation and internal competency development that best enables the large organization to constantly renew itself through game-changing innovation.

## The Radical Innovation Research Program at Rensselaer

*Overview.* The Lally School of Management and Technology at Rensselaer Polytechnic Institute has been home to the Radical Innovation Research Program since 1995. The research program has occurred in two phases and it has been sponsored throughout by the Industrial Research Institute, a professional organization of R&D Directors and CTO's of Fortune 1000 U.S. based companies.

Phase I, conducted from 1995-2000, tracked projects that were ongoing in large established companies that senior technical leadership identified as having the potential to be breakthroughs, should they succeed. So the unit of analysis for the first 5 years of study was the individual project. We believed that, by tracking projects identified by senior leaders as having breakthrough potential as they were being nurtured within their companies, we could at least describe what companies are doing, the extent to which those practices differ from incremental innovation practices, and begin to arrive at some theories for prescription that could be tested more conventionally. Projects were qualified into the study if they had an identified team and a budget, and had the potential to offer either a) new to the world performance features, b) significant (5-10x) improvement in known features, or c) significant (30-50%) reduction in cost.

*Key Learning, Phase I:* Tracking the projects over 5 years led to a number of important insights regarding the challenges that RI project teams face in large established companies. We provided our findings in the book *Radical Innovation: How Mature Firms Can Outsmart Upstarts* (HBS Press, 2000) and the series of papers listed on our website (www.lallyschool.rpi.edu/programs). We identified 4 dimensions of uncertainty and 7 challenges that companies faced in maturing radical innovations. We noted that, although RI was in fact occurring, appropriate management practices were ad hoc, unsystematically applied, and occurred on an exception basis. They were not recognized as legitimate practices or treated as part of the routines of the business. These findings led us to ask the higher level question of how companies could build a capability to enable RI to happen over and over rather than relying on singular strong willed highly gifted individual project leaders who had access to a senior executive sponsor.

In Phase II, carried out from 2001-2005 we have studied companies who have a declared strategic intent to evolve a radical innovation capability. The unit of analysis for phase II was not the project, but the Corporate Radical Innovation initiative, i.e. the building of a competency to do radical innovation over and over. Companies have tried and failed to build organic growth and renewal engines. Sometimes called incubators, sometimes called corporate venturing organizations, and sometimes called Radical Innovation hubs, these are organizational entities charged with finding the new, 'really big' growth opportunities for large, established, sometimes stagnant companies. Yet history shows that very few of these internal organic growth organizations a) have lasted very long AND b) have had real impact on their companies' growth and renewal patterns.

The formal objectives of Phase II are to understand how organizations can systematically develop and sustain their RI capabilities. Our conceptual framework has been that RI cannot be managed as a process like incremental innovation can, but rather requires a management system of multiple elements aligned as a system (O'Connor 2005).

*Sample.* Participating firms are large industrial North American based companies. Phase I firms are termed Cohort I, and Phase II is comprised of two sets of companies, Cohort II and Cohort III. Ten firms participated in Phase I, including Air Products, Analog Devices, Dupont, GE, General Motors, IBM, Nortel Networks, Polaroid, Texas Instruments and United Technologies. In Phase II, a total of twenty-one companies participated across the two cohort groups, including four from Phase I. Examples of Phase II companies include 3M, Corning, GE, Dupont, Intel, and Hewlett-Packard.

Our methodological approach is a longitudinal, cross case approach (Eisenhardt 1989; Yin 1994), with the added component of a multidisciplinary research team, as documented in O'Connor et. al. (2003). The approach for Phase II is the same. Sample and methodological details can be found in O'Connor and DeMartino (2005). A total of 143 interviews were conducted for Phase II's initial round of data collection, between nine and fourteen managers per company. Four rounds of follow up interviews have been completed to date, for a total of 224 interviews.

## Results and Insights

1. **Firms are investing in building a radical innovation capability much more today than they were ten years ago.**

Based on the project level data in Phase I and, later, the company level data gained in Phase II, it is clear that Firms are becoming increasingly sophisticated in building a radical innovation capability. They recognize the need for it, are investing in improving theirs, and recognize it as more than a process, but in fact a complex system. Of the ten companies in Cohort I, only 2 had a programmatic approach to managing radical innovation. By 2000, 4 of the companies that were cohort I companies had evolved a more sophisticated strategic intent and programmatic approach such that they opted to participate with us in Phase II. In addition, the number of companies that have a recognized, identifiable RI group or program or strategic intent was overwhelming.

Cohort III was formed, in fact, on the basis of companies contacting us to learn from the research and to network with other companies that were doing this well. So we observe that the trend for finding new paths to growth via highly innovative products and businesses is of keen interest and importance to large companies, much more so today than it appeared to be in 1995 when the research program began.

**2. Radical innovation is not a single capability. Rather, it is comprised of at least 3 distinctive sets of competencies: The Discovery-Incubation-Acceleration model.**

We have traced the organizational structures of the twelve cases in Phase II, and their evolution as they confronted particular challenges over time (O'Connor and DeMartino 2005). This exercise provides insight into the competencies required to develop a mature radical innovation capability. We identify three such competencies--discovery, incubation, and acceleration—each of which requires distinctive types of expertise and processes (Figure 2).

*Discovery.* A discovery capability involves activities that create, recognize, elaborate, and articulate RI opportunities. The skills needed are exploratory, conceptualization skills, both in terms of technical, scientific discovery and external hunting for opportunities. One of our Cohort III firms distinguishes between invention and discovery. Invention is the creation of something that was previously unknown. Discovery is becoming aware of something that may be known in other venues but was not known to the company. RI activities can include invention, but needn't always, according to our companies. This implies that a mature discovery capability includes not only internally focused laboratory research that industrial R&D laboratory scientists perform (witnessed in the vast majority of our sample companies), but also activities that embrace the open innovation concept.

*Incubation.* The analysis also suggests that an *incubation* capability is necessary for radical innovation. Whereas discovery competencies generate or recognize RI opportunities, the *incubation competency* involves activity that matures radical opportunities into business proposals. A business proposal is a working hypothesis about what the technology platform could enable in the market, what the market space will ultimately look like, and what the business model will be. Incubation is not complete until that proposal (or, more likely, a number of proposals, based on the initial discovery) has been tested in the market, with a working prototype.

The skills needed for incubation are experimentation and interaction skills. Experiments are conducted not only on the technical front, but, simultaneously for market learning, market creation and for testing the match of the business proposal against the company's strategic intent.

*Acceleration.* Acceleration activities ramp up the fledgling business to a point where it can stand on its own relative to other business platforms in the ultimate receiving unit. Whereas incubation reduces market and technical uncertainty through experimentation and learning, acceleration focuses on building a business to a level of some predictability in terms of sales and operations. As one Radical Innovation Director notes:

> "*I need a landing zone for projects that the business unit does not feel comfortable with. If I transfer these projects too early, the business unit leadership lets them die. I need a place to grow them until they can compete with ongoing businesses in the current operating units for resources and attention.*"

The skills needed are those required for managing high growth businesses. Acceleration involves exploitation rather than either exploration (which Discovery requires) or experimentation (which Incubation requires). The activities of acceleration include investing to build the business and its necessary infrastructure, focusing and responding to market leads and opportunities, and beginning to institute repeatable processes for typical business processes such as manufacturing and order delivery, customer contact and support. Acceleration involves turning early customer leads into a set of qualified customers and predictable sales forecasts. Similar to an independent start up firm in first stage growth, acceleration pursues top line revenue rather than bottom line profitability. Once a radical innovation program is generating profitable returns, it can be integrated into an existing business unit with less chance of neglect. It may also become a stand alone business unit or spin-out with P&L responsibilities.

**3. Open Innovation is Manifested Differently in Discovery, Incubation and Acceleration.**

While we note that each of these three competencies is required to enable a sustainable RI capability, we also note that Open Innovation is apparent across our companies in each of these aspects, and, we believe as do our participating companies, offers the possibility of speeding the arduous lifecycle of radical innovation. As mentioned in Ch. 1 of this book, it's an open question as to whether OI will further the RI cause or in fact drive companies to seek technologies they can quickly commercialize. The participating companies in this study do not perceive this tradeoff, but rather are experimenting with ways to engage in open innovation that further their RI capability development efforts. In other words, a major part of many of the company's efforts to develop an RI capability involves developing a capability to use the OI model appropriately for that cause. However, they are not yet completely successful. Documented in this section are the ways in which they are engaging in OI to further RI objectives, and the challenges they face in doing so.

Discovery and Open Innovation: What's happening and what's missing? As mentioned, Discovery activities observed in the sample companies include not only an investment in basic R&D, but also hunting inside and outside the company for ideas and opportunities and licensing technologies or placing equity investments in small firms that hold promise. Ten of the 12 cohort II companies are involved in each of these activities simultaneously, to increase the opportunity space for radical innovation. Nine of our twelve firms noted external programs to locate outside opportunities through universities, venture capital investments, or strategic alliances. One of the cohort III firms describes placing "eyes and ears" investments in small companies to maintain a seat on the board so the large firm can understand the novel technology domain that the start up is exploring, to help reduce the company's risk through quick, cheap learning.

*New Roles Emerging.* A number of formal organizational roles and structures are emerging to create, recognize, or elaborate radical innovation opportunities in the discovery phase. Four companies relied heavily on a relatively large number of dedicated research staff personally responsible for developing radically innovative ideas, which were generated from technical interest primarily. However, each one of these companies (and most of the remaining sample companies) were members of research centers at universities so they could stay abreast of new discoveries that could be leveraged into their innovation plans. Five sample firms used dedicated radical innovation "hunters" and/or “gatherers” responsible for identifying radical innovations within internal and/or external environments. An idea hunter is an individual who actively seeks out RI ideas. They may conduct “idea generation workshops” in the business units, or visit laboratory scientists working on exploratory research and identify opportunities that are raised as potential business proposals.

In one company, for example, the RI group became the home for the founders of small companies that the larger organization had acquired. The RI group found these people very valuable as idea hunters because a) they had rich external networks due to their stature and previous activities as the founder of an organization, and b) their skill at opportunity recognition given their entrepreneurial experience in starting up and running a company. Another company, formed an ‘externalization’ team devoted to the development of future trend analyses based on visits to universities, and built a “hunters’ network” of creative individuals throughout the company as well. In another company, a permanent team of technical and business development middle managers comprised the “Technology Identification Process” team, challenged with finding new opportunities to help fuel R&D projects.

Three companies are experimenting with “exploratory marketing groups” which serve as a mechanism to proactively discover radical innovation opportunities at the technology/market nexus. Finally, one sample company relied upon an informal network of external contractors to generate and develop wild ideas and inventions. This network was maintained and funded by a senior executive who elected not to bring them within the company for fear that their creativity would be stifled.

In contrast to idea hunters, a "gatherer" is a central locus for idea generators to turn to for help. It is a more passive role than the idea hunter. Thus, 3M, Dupont, and Kodak have websites for inventors from outside the company to propose ideas. Nearly all the companies in the sample had an idea tracker system for employees within the companies to contribute ideas. These are screened and evaluated. From an internal perspective, employees or researchers who have ideas but do not know where to turn for funding or help articulating them or even guidance in what to do next use idea gatherers for coaching. Idea gatherers were present in 6 companies.

Several firms used a modified open innovation model in that they focused heavily on sharing with and borrowing ideas across divisions of the firm, so the openness was within the company so that company resources could be well leveraged. In one case, a technology board of senior leaders across the divisions met to share information and ideas on a monthly basis. Another divisional CEO within a large diversified company, whose businesses were primarily in low margin consumer product categories began pirating researchers and product managers from the company's pharmaceutical division to help germinate cross-industry ideas.

Thus we observe that ideas come not just from the scientist's bench, but from groups of creative people within the organization, from idea hunters who uncover ideas inside and outside the organization, from formal relationships with universities and venture capital funds, from efforts to cross-fertilize within an organization across divisional and industry boundaries, and from single creative individuals who may be maintained outside the organization but whose efforts are dedicated to the organization's needs. A broad spectrum of structural mechanisms exist to ensure a rich Discovery competency for the company. When asked to describe the rationale behind the various Discovery mechanisms the companies were using, they mentioned using exploratory marketing and external idea hunters to find “system level problems that we can contribute to solving,” and “to talk with potential customer/partners that we currently don’t know.” Venture investing, university liaison and targeted search for small companies were described as “eyes and ears investments to find promising new technologies that are emerging,” or “to solve a competency gap.” Finally, one company mentioned hiring external contract inventors for the sole purpose of ensuring that creativity was maintained without being hampered by corporate norms and bureaucratic burdens.

*Observed Challenges with Open Innovation and the Discovery Capability.* While nearly every one of the sample companies recognized the value of the open innovation model, they are struggling in the discovery phase with several issues. Firms currently lack the capability to create “development partnerships,” i.e. relationships with other firms that are neither hands-off licensing agreements or subcontract relationships nor highly integrated joint ventures. In the radical innovation domain, the outcome of any discovery activity is highly unpredictable. In addition, since firms are pushing the boundaries of their capabilities and expertise, partnerships for joint development are particularly appropriate means for accessing new knowledge and expertise quickly. But companies are confused about how to structure such agreements given the vast array of potential outcomes of the development project. In one company, a partnership was needed for manufacturing of the product. The manufacturing process itself required major innovation, given that the technology was heretofore not manufactured in large scale and was rather different from previous approaches. The manufacturing partner was never able to generate the process innovations necessary; these were ultimately developed in the principal firm's R&D lab. The partnership was never actively leveraged and the manufacturing firm became a subcontractor. In another case, a large firm relied on a small contract R&D company for much of the ceramics based innovation that was required in a particular project but that was only resident in a few of the large firm's key scientists. The two companies became tightly partnered in the development work. The smaller firm wanted to be acquired ultimately, but actually had no production capability, which was what the larger firm ultimately needed, and so the smaller firm was disappointed about missing out on the value of the innovation they had contributed to so intensively.

Finally, the open innovation model, as it invades the Discovery process, may be interpreted in ways that threaten the role of R&D in large established companies. Will R&D now be evaluators and 'assemblers' of technology, much as the large automotive companies became large scale assemblers of cars, but created almost none of the technology in house? How much component level expertise is required, in order to be an effective systems integrator of technology? How much resident R&D expertise in general is required to enable radical innovation in a large established company? While open innovation exemplars like IBM, Intel, and Procter & Gamble maintain deep ongoing internal R&D programs, many other companies may be tempted to utilize the open innovation concept as a pretext for hollowing out their internal technical capabilities.

<u>Incubation and Open Innovation: What's happening and what's missing?</u>

Incubation requires experimenting with the opportunity such that, ultimately, a new market can be created. It cannot occur, even by luck, within the confines of the company.

Interaction in an extensive manner with the market is critical to understanding the aspects of the discovery that are valued, by whom, and the mechanisms by which those can best be delivered to the market (Lynn, Morone and Paulson 1996, O'Connor 1998). Preliminary answers to those questions then drive technical development. A case example helps clarify this critical issue:

*Intelligent Packaging.* Intelligent Packaging is a methodology for unique identification of a package through wireless technology. It is like a bar code that need not be scanned, or even seen by the naked eye. That ability allows for inventory control to be handled from the raw material stage through to final assembly in a radically new, more specific manner. It reduces uncertainty about what stock levels are at each step in the value chain. To an ERP system this is worth 1-2% of sales per year in reduced inventory shrinkage and pilfering. Another application may be for security purposes in airports. The possibilities are endless, but, as is typical, the costs presently are too high to justify adoption in many major industries.

In one of our participating companies, the inventor of this technology, Paul, described his early experiences in the discovery phase. He knew the invention was exciting, but, he had reached a stage in his technical exploration that he didn't know what to do next. He was actually receiving negative performance evaluations because he was not providing immediate, direct support to business unit related products. He stated,

> *I could've done what most research scientists do in that situation…ask for more money and a bigger lab. However, I realized I still wouldn't know what to do in that lab on Monday morning. I got forced out of the research lab because I didn't know who my customer was {so which business unit would take this on]…The market didn't exist…so I couldn't develop the technology without studying the market. But if I wrote papers about the market that wasn't really a technical research problem. So I wandered down the hall and described my discovery to Linda, [who worked in the group responsible for nurturing radical innovations in*

*the company]. She asked me a lot of questions but convinced me that we had to start talking about this in the market. We found and joined a university center that had 60 members companies whose purpose was to discuss standards in the intelligent packaging domain.*

*I could've made up some stories and gotten a lab and a team. But it would only be because I didn't know what to do. The competitive intelligence we've gathered has convinced me that the places we thought this would work would not have worked out.*

The champion of the project (Ron) told us

*This could have remained a 'research project,' but it wouldn't have worked because it would've been treated as a technical problem. Really, though, it's a business problem.*

To study the markets that didn't yet exist, Paul worked with Linda to conduct a gap analysis on the technology. The small team started looking for companies to buy to catapult them forward in the technology. The inventor (Paul) later stated, "I didn't realize that we were getting a lot of competitive intelligence in the industry because of the due diligence we were doing on these companies. We tried that for 9 months or so…but didn't get anywhere because we talked to small company startup founders who kept trying to hose us on the price. We asked "How will this pay itself off?" This caused me, a technical person to see how the financial side is important to me too."

Ron ultimately challenged them to stop looking for acquisition candidates to help them drive the business, and decide that they could evolve the opportunity in a manner that leveraged the company's core competencies. This reorientation would have dramatic influence on the business model, but that could not have happened without their early market interactions. Paul described this clarification:

*We had become experts on the technical side by joining that university center and conducting those due diligence interviews. We knew where the technology was falling short of the market...what it needed to do. A lot of people were talking* *about characteristics of the technology that weren't really important. We concluded that because we weren't an RFID company proper, but rather a commodities manufacturing company, we might see something a little different here. We could take the technology that exists today and apply it in a way that makes its weaknesses irrelevant. We could do this because that's how a commodities company thinks. We couldn't have done it if we weren't in the university center…because we could see all the mistakes the other members were making in how they were pitching it. Being from a different industry helped us see the problem differently.*

The team began to work with market partners that distributed lower volume high value added goods rather than high volume bulk goods, so the cost could be justified. The project continues and is regarded as an impending major success for the firm at this writing.

We note that incubation was neither recognized as a necessary activity nor systematically engaged in across the companies. Lynn, Morone and Paulson (1996) have documented the critical importance of this sort of 'probe and learn' activity, but few companies recognize the critical interconnection and simultaneity between technology development and new market creation. Of the 12 companies in cohort II, only one had a mature incubation capability at the outset of their RI initiative. Ultimately, however, 9 companies recognized the need for this activity and attempted to build it in some way. Only a small proportion of the cases ever achieved a high level of incubation competency, though many of the companies expressed lack of business acumen and inability to build businesses linked to the company's strategic intent as challenges they faced (O'Connor and DeMartino 2005). Incubation becomes increasingly important as the opportunity poses challenges to the company's current business model and therefore to finding an ultimate home for the new business opportunity. When companies do not engage in incubation, they risk leveraging the full value of the opportunity because they typically ‘force-fit’ it into a current business and adopt the business model of that SBU (Rice, Leifer and O’Connor 2002).

One very interesting practice we have noted that stimulates incubation opportunities is picture in Figure 3. Dupont’s biodegradeable polyester, Biomax® was one of the projects studied in Phase I. The New Business Development director, situated in the R&D lab, acted as the role of idea hunter and gatherer described earlier. But he also helped nurture those ideas into business proposals with his team. The advertisement pictured in Figure 3 was run when Biomax® was struggling to find application niches to help guide its continued development. The ad does not provide the secrets to the material, but offers enough information that potential codevelopment partners’ interest would be stimulated. The ad was run in trade and professional journals such as Chemical Weekly and Scientific American. It generated over 100 inquiries and resulted in more than 30 initial trials of the material in various application domains. The NBD director used this technique more than once, and it was becoming a useful practice. However, when he left the firm, the practice was forgotten.

*Observed Challenges with Open Innovation and Incubation.* It is clear that getting involved with the market early and often is of critical importance to learning about the value of the potential business and to help guide the direction of technology development. Two issues emerge. The first is how to define which companies to work with. If left to the current organizational structures and roles, marketing people tend to take on the responsibility of identifying customer partners. But in creating new markets, current customers are frequently the worst possible choices (Christensen, 1997). Greenfield methods for finding interested parties, like the advertising mechanism Dupont used, are important.

Secondly, the probe and learn methodology for market learning and market creation has been viewed increasingly as a legitimate, accepted process in the literature. However, we note that questions remain about how to investigate applications and business models optimally using this approach. One question that arises is whether probes should be conducted serially (to allow learning to occur between each probe) or in parallel, working with multiple customer partners in multiple application domains. Participating companies related that having too many partners at the same time requires too many resources. However, it appears that this could substantially shorten the time involved to understand the boundaries of the technology's value to the market, and thus speed commercialization. A possible line of future inquiry is how to optimize the number, sequencing and selection of partners to work with to maximize learning output.

<u>Acceleration and Open Innovation: What's Happening and What's Missing?</u>

Acceleration is not a major issue for radical innovation opportunities that fall completely in line with a particular business unit. So long as there is high level communication and, typically, shared funding between the receiving unit and R&D, these projects can be commercialized within prescribed application spaces, business models, and infrastructures that the organization typically uses. However, when the opportunity requires any stretching of the customer set, the business model, the manufacturing processes, or the value proposition that a business unit is used to, transition problems occur (Rice, Leifer and O'Connor 2002). The fact is that most radical innovations, because they are radical, do not fall neatly within the scope of the current businesses.

Acceleration is the set of activities needed to build the business to a point where it can compete within its eventual home (should it be one of the existing business units) for resources, attention and priority with the ongoing lines of business.

In our Cohort II samples of companies, 6 firms created permanent organizations to accelerate businesses, some of which were located within a division but were given senior management level oversight (4 cases) and others (2 cases) located outside the current divisions, reporting to the Corporate Officers directly.

Open innovation is not as pertinent in this phase, since fledgling businesses are generally free to establish their own partnerships and customer base. In fact, that is the purpose of acceleration. However, two points arise in the data that should be mentioned.

In one case, a brand new technology platform was developed within R&D, and the company wanted that platform to spawn a number of opportunities that would be useful to many different business units. Because the technology was so new, the businesses hesitated to invest in project ideas emanating from the platform group. The group became frustrated and hired Opportunity Brokers to shop the technology to external companies for potential co-development partnerships. Setting up the external competition quickly caught the attention of the company's senior leadership, who had invested in this development effort specifically because they viewed it as a strategically important growth path for the company.[2] This is the use of an open innovation model for the purposes of expediting focused attention to the project, and, in this case, it worked.

[2] This was similar in spirit to the effect Chesbrough (2003) observed in Lucent's Bell Labs, when an internal venture capital arm was established to commercialize technologies that otherwise would not have been used by the internal businesses. The presence of a second path to market created internal competition that prompted faster and more thorough consideration of technology projects within Lucent.

The platform is now its own business unit with a general manager and is on the path to significant revenue streams.

Secondly, we and others note that new businesses do not get built quickly. Sometimes the expectations on magnitude of the RI business are so heightened that early market entries appear disappointing. The theme of interacting with the market so that the market learns about the technology is again key in the acceleration phase. None of the projects in our first study achieved a 'killer application' early in their commercialization phase. Figure 4 shows the case of Analog Devices' accelerometer. The company's vision of the killer application was the automotive market, first for airbag detonation and then in other applications. The company sacrificed early profits to gain those volumes and manufacturing learning curve advantages, but the market, actually evolved way beyond that, and, in fact, brought profitable applications to Analog because they saw the potential as Analog's accelerometer technology became understood. The point of Figure 4 is that application migration occurs, meaning that an early entry application may be in a niche market, but others arise and, in fact, seek out the innovating company to learn more. So being too driven towards any single application space and expecting a killer application is not in alignment with reality. It is critical to be open to inquiries from fields far removed from those originally envisioned.

## Concluding Thoughts: Radical Innovation Must be Open Innovation

It is clear that open innovation, if managed in a balanced way with internal capability development, can help speed Radical Innovation through its emphasis on interaction and networks. In fact, Radical Innovation efforts in large companies have not been sustained, and Open Innovation is quickly becoming viewed as a critical aspect to helping gain the efficiencies of learning necessary to make RI sustainable. Any company choosing to develop radical innovations is, by definition, stretching the boundary of what is already known, certainly within its own domain. Accessing technologies, market partners, and expertise in arenas that are dramatically different from the company's core enables creativity, opportunity recognition, and connectivity into new domains. However, a number of questions remain for research in this unchartered space.

From the perspective of Discovery capabilities within a firm, we need a better understanding of appropriate agreement terms with partners who contribute sources of technology and development know-how. Agency theory and balance of power issues between firms are stalling progress in this regard. Firms continue to hesitate to engage in open innovation because they are concerned about intellectual property ownership issues. In addition, the open innovation model raises the issue of the role of R&D in the large established company. How does this impact the core competency of an organization that has heretofore prided itself on its discovery capability? What, in fact, is the core competence of a company who competes on the basis of technological innovation, given the challenges posed by the open innovation model? What are the boundaries of Open Innovation? How can we think about radical innovation as a dynamic capability (Teece, Pisano and Shuen, 1997), and Open innovation's role in this?

In terms of incubation, a critical theme that comes through in our data is to engage in early market participation, with usable prototypes. But most of these prototypes are clumsy and unrefined. How open can we be, how early on, with "klugey" technology?

And how is this relationship with potential new markets best managed, given that customer-partners' expectations will never be met?

In terms of Acceleration, how does the OI model extend to customer partners? How can it help us understand the appropriate pace of a radical innovation's impact on the market? Can it help speed that? Can it help set realistic expectations for senior management, so that appropriate metrics are used to gauge a radical innovation's success over time? These issues plague large companies today.

Finally, some overall questions arise regarding the interaction between Open Innovation and the radical innovation competency model defined in this chapter. First, what are the relative risks and rewards of using an open innovation model across Discovery, Incubation and Acceleration? So far, attention has primarily been paid to OI in the Discovery aspect of Radical innovation. Developing the model further with regard to Incubation and Acceleration seems paramount for successful commercialization and new market creation.

Additionally, how is Open Innovation leveraged differentially across RI opportunities that are aligned with the firm's current business models versus those that do not fit? It is fairly clear that attempts to move into white spaces, that are unaligned with the firm's current business models, require partnerships and openness. But territoriality, the desire for economies of scale and scope, and competitive dominance are dynamics that exist in the aligned opportunity space. This issue deserves further investigation.

Finally, how critical is leveraging internal strengths and networks compared to those outside the organization? The use of internal networks is a critical success factor that arises in our radical innovation research data, and that effect appears initially to be stronger that engaging in external networking, which open innovation prescribes. Again, a systematic exploration of the relative impacts of internal networks versus external partnerships in large companies is warranted.

We have an important research agenda ahead. It will certainly have enormous influence on management practice, and hopefully can help enable successful radical innovation in large established firms.

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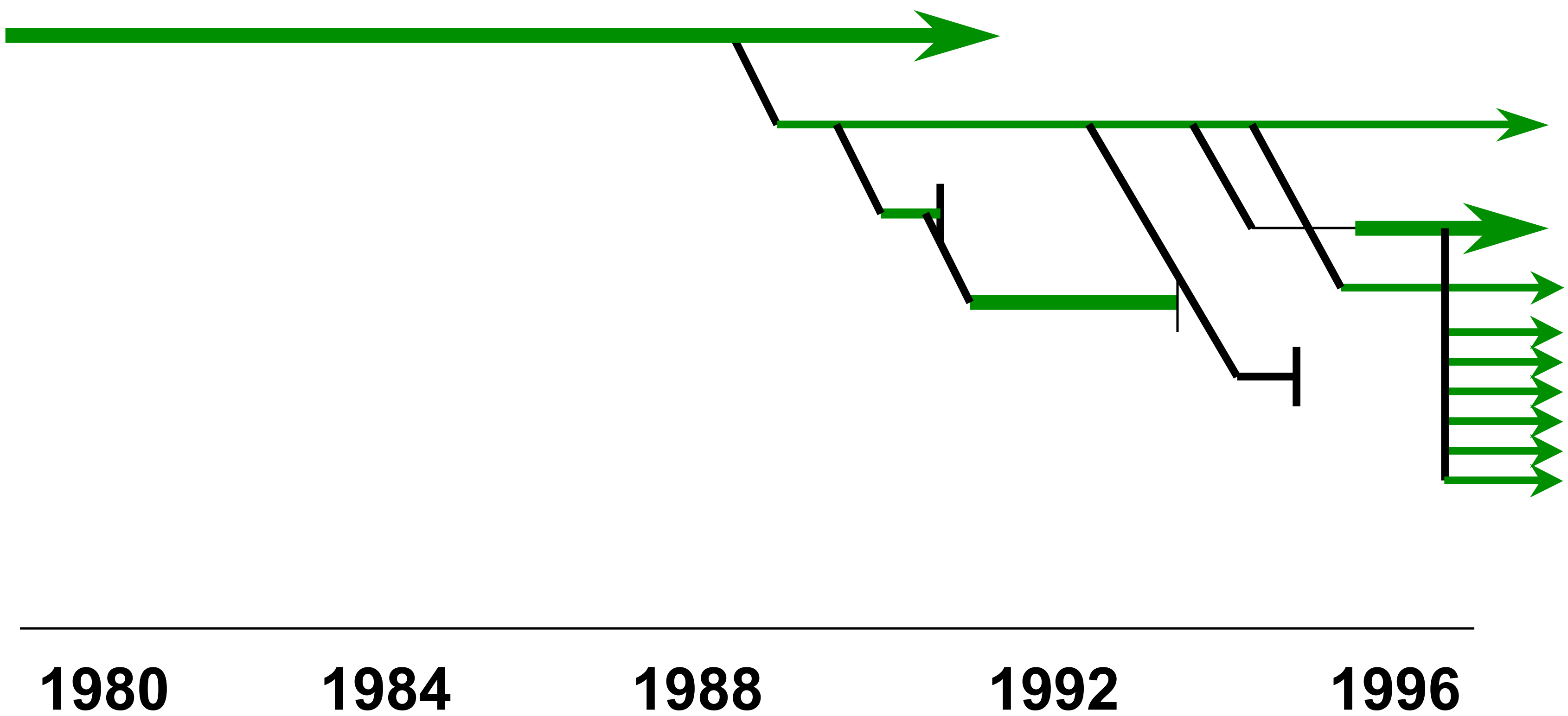
Figure 4.1
Texas Instruments' Digital Micromirror Device (DMD®)
Timeline



## Figure 4.2
## RI requires three sets of competencies

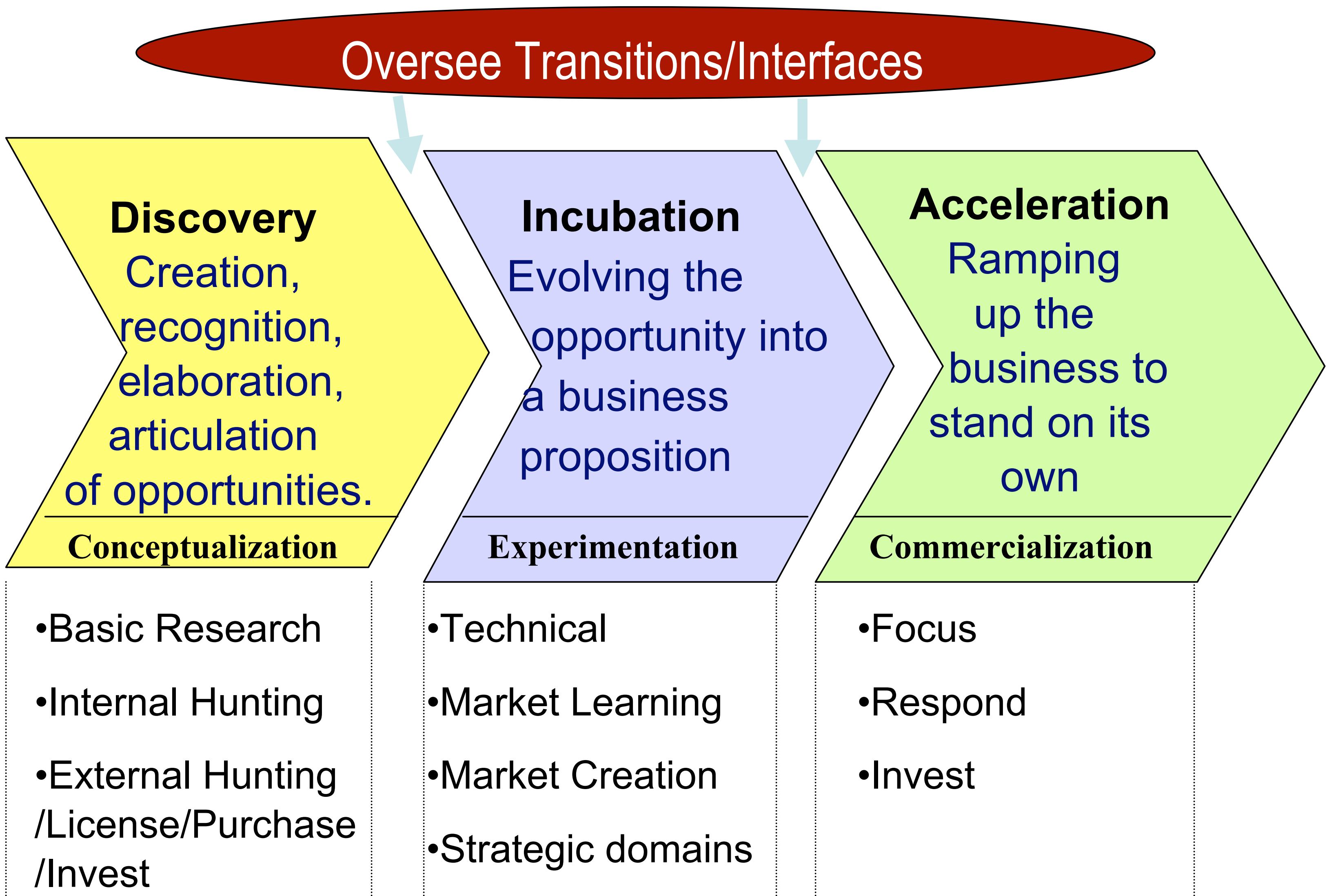


Figure 4.3 : Dupont's Biomax® Ad

Figure 4.4: Application Migration
Analog Devices' Accelerometer MEMS Device