ENGINES OF PROGRESS: DESIGNING AND RUNNING ENTREPRENEURIAL VEHICLES IN ESTABLISHED COMPANIES; RAYTHEON'S NEW PRODUCT CENTER, 1969–1989

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THE PROBLEM OF GENERATING AND SUSTAINING ENTREPRENEURSHIP IN ESTABLISHED companies contains a major paradox: how to *routinize and manage* a process often assumed to be *spontaneous and opportunistic*. Scholars of entrepreneurship and innovation stress the emergent, chaotic, and unpredictable character of new ventures and innovation projects (e.g., Quinn 1985; Kao 1989)—termed "newstream" activities (Kanter 1989), or activities producing a new revenue flow. Such newstream chaos and uncertainty pose a sharp contrast to the more orderly management process for on-going operations in the organizational "mainstream," because of necessary differences in outlook between entrepreneurs and administrators/bureaucrats as well as differences in the kinds of tasks they face (Kanter 1985; Stevenson and Gumpert 1986; Kanter 1989, pp. 201–214).

Thus, research has tended to demonstrate that entrepreneurship is difficult for established companies to tolerate, let alone manage, for more than a short period of time. Of course, established companies can organize in ways that promote more innovation in their mainstream businesses, and even occasionally spawn new businesses (Kanter 1983, Peters and Waterman 1982); and an occasional major, strategic new venture with large investment can succeed (Burgelman and Sayles 1986). But many documented efforts to systematically produce new ventures on a large scale over a long period of time, such as new venture

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departments, have been disappointing to their corporate sponsors and, hence, short-lived (Fast 1979, Sykes 1986).

Is it possible to *routinize the unpredictable*—that is, to design a mechanism that will reliably and continuously produce newstreams?

The Harvard Business School Research Program on Entrepreneurship in Established Companies undertook to address this question by examining a variety of entrepreneurial vehicles (programs driving the creation of new revenue streams through new ideas) in large North American corporations. Between 1986 and 1989, the research team studied eight corporate venturing programs in depth, in a range of industries, to compare and contrast the ways in which companies could organize to find, nurture, and use newstream activities as well as the viability of each approach. The eight sites were selected to maximize differences in strategic intent and operations (see Kanter 1989a on methodology; Kanter 1989b on theory; Kanter 1990). Further differences emerged from the dynamic nature of the vehicles themselves, which had complicated histories before the research began, changed considerably in form and intent during the study period, and were continuing to evolve as the formal research was completed. The dynamism was a result, not only of the normal flux and change in corporate life, but also of the additional problem of defining the appropriate relationship between mainstream and newstream.

A newstream program is an attempt to "bureaucratize entrepreneurship," that is, subject entrepreneurship to routines and controls, in order to capture its benefits without losing its essence. Such a program is an attempt to harness creativity and transform it into new ventures—without diluting creativity by the addition of commercialization requirements or sacrificing relevance on the altar of creativity. The effective juggling of both creativity and relevance, producing a regular flow of new revenue sources at a modest level—and doing this for 20 years—is the central theme of the Raytheon New Products Center case.

Raytheon's New Products Center (NPC) demonstrates how newstream development efforts can be effectively linked to, and contribute to the revitalization of, mainstream businesses. It also shows how the creativity and entrepreneurial spirit that can conceive of new opportunities and develop them can coexist with disciplines and controls. As Angle (1989) has observed, creativity is not necessarily innovation. The issue for organizations is not necessarily finding creative people, because the potential for creativity may be widespread in the population (e.g., Campbell 1960, Langer 1989) and may be a matter of education or situation as well as individual traits. Subject-matter expertise, social or political skill, and contacts outside the field of primary focus—as a stimulus to new thinking—have been correlated with the creativity of research scientists, for example (Amabile 1988). At the same time, however, some personal attributes often associated with creativity have led analysts to assume that creative people are "hard to manage"; for example, self-motivation or risk-orientation. And creativity has been assumed to be a spontaneous, unpredictable process not subject to the usual managerial controls.

Therefore, the major organizational issue is the *integration* of the creative process into the organizational mainstream to produce innovation. Clearly, managers influence creative tasks by defining them and setting expectations, framing the problem, and offering parameters such as deadlines, uses, etc. Michael Eisner, president of Walt Disney, linked discipline and creativity, remarking that "the only people I let roll around the floor having a tantrum are my three-year-olds" (Kao 1989, pp. 23–24). As to whether or not an organization can have creativity on demand, George Freedman, founder of the Raytheon New Products Center, told the field team that the simplest way to "manage" creativity is to provide a deadline.

The Raytheon NPC case illustrates how creativity can be routinely produced to serve

corporate purposes. It also illustrates the political and organizational side of corporate entrepreneurship, because effective management of the organizational context was responsible for this newstream program's success. The Raytheon NPC counts as one of two long-lived entrepreneurial vehicles among the eight corporate newstream programs studied. As such, it has been the subject of much interest from visitors eager to start similar programs; founder Freedman wrote a book (Freedman 1989; see also Freedman 1986, Kanter 1990). But the very reasons for its longevity—modest expectations, involvement in prototype development rather than commercialization—make it seem less "entrepreneurial" to some observers.

RAYTHEON'S NPC, 1969–1989

Raytheon's NPC, formally established in 1969 as part of the Microwave and Power Tube Division, had been an independent facility since 1976. Operating on an eventual budget of approximately $3 million per year, and in 1986 moving to a newly dedicated facility in a Burlington, MA technology park, the New Products Center assisted Raytheon companies in domestic, commercial, and industrial markets, but primarily in the major appliance area, to develop new products, product extensions, and new lines of business. The NPC worked on as many as 60 projects at one time, and a critical part of the director's job was assigning priorities to projects and ensuring that their resources were being effectively deployed. The NPC did not charge its "clients" (the Raytheon product divisions) for its services; this fostered greater acceptance and use of the facility. Some issues and problems were routed to the NPC from the head office; NPC administrators developed a network of contacts throughout the company which allowed them quickly to direct the problems to the appropriate problem solver.

The NPC was purposely kept small. The stated NPC philosophy was that many of the best innovations come from constant interaction and exchange of ideas among a small group; 50 people was thus held to be an upper limit, to avoid segmenting the staff into separate departments, which would jeopardize the creative process that results from interaction among different disciplines (Kanter 1983). Between 1969 and 1989, over $50 million had been invested in the NPC. During that time, in excess of 50 products developed at the NPC were accepted by the clients; estimates of revenues generated by these projects were in the range of several hundred million dollars per year. In addition, at least one stand-alone business was developed by NPC staff, the industrial micro-waving unit.

While the NPC did research, it was a business generator rather than an R&D lab. Raytheon divisions each retained their own captive R&D organizations. The NPC served mainly the commercial divisions, but not in the same way as the traditional R&D did. The NPC stressed development—innovation in the interests of new products and business lines. Thus, the staff demonstrated competence in market assessment and manufacturing process as well as the technologies needed for new products.

THE RAYTHEON COMPANY

Founded in Cambridge, MA in 1922, by 1989 Raytheon was a diversified, high-technology company ranked among *Fortune*'s 100 largest industrial corporations. Before a major diversification program that began in 1964, Raytheon was primarily a producer of transmitting tubes, radar systems, and missile guidance systems for the United States government. In 1964, when sales amounted to $454 million, 83% of this total was accounted for by gov-

EXHIBIT 1

Raytheon's Business Segments

Electronics

Largest business area: missile systems, surveillance radars, air-traffic control systems, military communications equipment, electronic and microwave components; semiconductor devices and other components; commercial products, including medical and marine equipment.

Aircraft Products

Beech Aircraft Corporation, a leading supplier of aircraft for general aviation: single- and twin-engine piston and turboprops, and business jets for corporations, commuter airlines, government and military organizations, private pilots; and missile targets for the government.

Major Appliances

Amana Refrigerators and *Caloric Corporation* (including *Modern Maid, Glenwood,* and *Sunray* brands) full-line appliance companies. *Speed Queen Company:* laundry equipment for home and commercial use.

Energy Services

United Engineers and Constructors: design, construction, and maintenance of electric power and industrial plants. *Seismograph Service Corporation.* geophysical exploration service for oil and gas. *The Badger Company:* design and construction of petroleum, petrochemicals, and chemical processing plants.

Other Lines

D.C. Heath and Company: educational publishing, including *Caedmon* spoken-word recordings and *Arabesque* classical recordings. *Cedarapids:* equipment for the road-building and construction industry. *Raytheon Service Company:* technical service and logistic support for government and commercial customers.

Source: Raytheon 1986 Annual Report.

ernment contracts. By 1985, when sales had grown to $6.4 billion, government business accounted for only half of this amount.

Raytheon's primary businesses involved electronics. Whereas the relative importance of military contracts had declined by 1989, Raytheon remained the Department of Defense's ninth largest prime contractor. Raytheon's other business areas included Aircraft Products, Major Appliances, and Energy Services (see Exhibit 1). In 1989, Raytheon employed more than 77,600 people in 80 facilities in 26 states, and another 24 facilities in Canada, Europe, and Japan. With 31,000 employees in Massachusetts alone, Raytheon ranked as the largest industrial employer in the state.

Raytheon was a research-intensive organization with a history of innovation. Since 1977, annual expenses for research and development fluctuated between 3 and 4% of sales. Major Raytheon innovations included:

- A rectifier tube that changed the shape and size of home radios
- A mass-production breakthrough on magnetron power tubes, which are the heart of radar systems
- The first guided missile to intercept and knock down an aircraft in flight
- The first interception and destruction of a ballistic missile by a guided missile
- The world's first electronic depth sounder
- The first application of microwave energy to the heating of food and the innovation and commercial introduction of microwave ovens.

The first microwave oven for home use, trademarked the Radarange, was introduced by Raytheon's Amana division in 1967. Amana, along with Speed Queen and Caloric, formed Raytheon's Major Appliance group. The group was the fifth largest major appliance company in the United States, with 1986 sales nearing $900 million. The most recent thrust of the group was to manufacture products, particularly for microwave ovens, for the mid-priced marked segment, for both first-time and replacement buyers.

Throughout the 1980s, all of the appliance group units looked for new markets and new lines of business. Amana, for example, added dishwashers as a step in offering a complete appliance line; the group was then able to bid on construction contracts that called for complete appliance packages. Speed Queen introduced the "no-coin" alternative to coin-operated washers and dryers. A dormitory at Bentley College in Waltham, MA was the site of a pilot project to test an apparatus that allows the customer to use a laundry card (similar to an ATM card) rather than coins. Although its original strength was in gas ranges, Caloric introduced the first electric range featuring Ultra-Ray broiler technology, something that has been available on gas ranges for some time.

The NPC was a vital link in the new business development process. It contributed to developing the laundry card and the technology for electric ranges, and it was instrumental in Caloric's entry into the field of microwave cooking when it developed industry-leading combination ovens, which added microwave-cooking capability to conventional stoves. In addition, the NPC received funding from the Laser Products division, a nonconsumer unit, to support development work on lasers. Raytheon's industrial microwave operation was a new business unit formed and staffed by NPC entrepreneurs, who left the NPC to run the business after they started it.

EVOLUTION OF RAYTHEON'S NPC

In the mid-1960s, George Freedman, a materials engineer with Raytheon, and a group of his colleagues, asked the company to allow them to form a separate new products group.

One impetus was shared aptitude for and love of creating new products; another might have been a movement among some peace-oriented engineers to resist working on war-related products. The engineers were often frustrated when too often they were reduced to "bootlegging"—working on new product projects on the sly, using funds appropriated from officially sanctioned projects. Because that money was, by definition, so scarce and piecemeal, the bootleg projects were carefully and efficiently managed (Freedman 1988). Whereas Freedman believed that bootlegging was an inappropriate practice for the development of new product ideas at Raytheon, the Raytheon culture made it hard for innovations to emerge outside of the rigid R&D structures already in place. Earlier in his 44-year career at Raytheon, Freedman had left to start his own venture. "That experience rendered me poor rather than

rich (the exact opposite of my original intention)," he later wrote, "but I don't regret it because it enriched my level of knowledge in the field of new ventures. . ." (Freedman 1988, p. 14). Thus, seeking to found a new products center was an outlet for Freedman's entrepreneurial desires, but in a protected corporate environment.

It took three years of persuasion and lobbying before the NPC was established. Four factors led to the ultimate decision by Raytheon to support an NPC:

1. Over a period of several years, Freedman had become friendly with people throughout Raytheon who had problems in the materials area. He soon had a portfolio of ideas and problems that could begin to justify the ongoing support of an innovation unit by Raytheon.
2. The microwave oven, which was introduced in 1967, was a huge success that proved the value of innovation and creativity. Such a visible success made Freedman's search for a corporate "champion" much simpler.
3. Freedman found a champion in Palmer Derby, a former MIT classmate who had risen to one of Raytheon's 25 vice-presidencies and was known as a frustrated inventor.
4. Freedman threatened to leave Raytheon.

Even these conditions were not sufficient to translate support into an actual center. Feeling that he had reached an impasse, Freedman contacted a friend in the public relations department, who showed him some products that had been successfully developed, and suggested that perhaps this would make an interesting news story. His colleague agreed. When the news broke in the newspapers, it appeared that the NPC had been established before it had actually been approved. Immediately the materials group began to receive calls from inside and outside of the company. After the story had been on television, Raytheon's stock rose by four points, an event that countered senior management annoyance about the inappropriate news release. Derby, then Assistant General Manager of Raytheon's Microwave and Power Tube Division, approved the NPC. Derby and Freedman had to act quickly, before senior management support waned, so they rented two "portable office" trailers to house the NPC.

The NPC began as an applied research group tied to a single business. It started under the aegis of the Microwave and Power Tube Division because of the hope that many innovations could be created from the microwave technology that Raytheon had pioneered, and, probably more important, because of Derby's sponsorship. The NPC's stay in the Power and Tube Division was short-lived, however, because of technological limitations. The NPC attempted to provide new sockets for microwave tubes; it did not produce a cooking tube to compete with Japan. Instead, the NPC started looking at different kinds of equipment, including heat-transfer units, sand molds, commercial pass-through cookers, and technology for tempering frozen beef—none of them tubes. Eventually, in 1976, the NPC became part of the corporate office. Still, the early show-of-faith sponsorship was essential to getting started, just as the research literature has shown (e.g., Souder 1981), because it permitted development of a track record to attract other support.

The NPC occupied its trailers for nearly a year, then moving to a small, shabby building in Waltham, MA, filled with gutted washing machines, sophisticated computer systems, and a microwave oven that doubled as a tool cabinet to save space. Freedman strongly believed that a development group needed the autonomy of its own space (Freedman 1988; see Kanter 1989, on newstream pressures for autonomy). There was no real plan, but since the company expected the NPC to be self-supporting, Freedman's "portfolio of problems" soon came into play. For the first seven years, the NPC led a hand-to-mouth existence

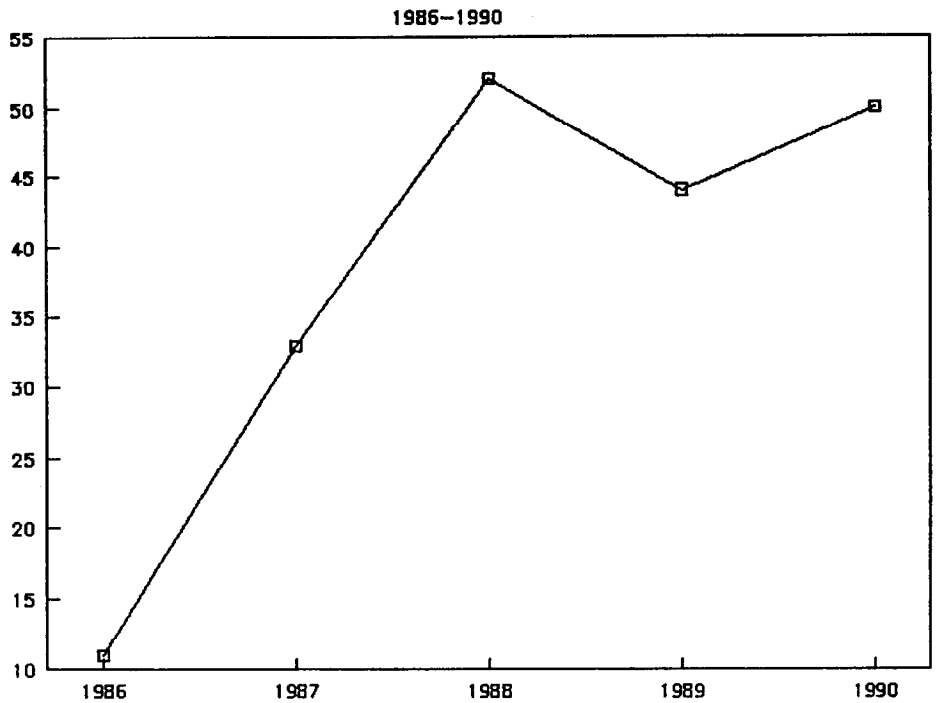

FIGURE 1 Number of patents, NPC engineers, 1986–1990.

by providing engineering support that would *occasionally* lead to the development of new products. The ratio of engineering support to new product development was about 5 to 1 until about 1976. The ratio reversed when the NPC moved to its corporate base and became a resource to Amana, Speed Queen, and Caloric (which a decade later accounted for nearly $1 billion of the corporation's $7 billion in sales).

Raytheon's insistence that the NPC be self-supporting was complicated by the unwillingness of managers to risk their budgets on an untested group of innovators. Engineers preferred to solve their own problems, so their acceptance of the NPC's services was additionally hindered by resistance on the part of mainstream business to outside influences, to anything "not invented here." Until Raytheon's top management was convinced its by track record to furnish the NPC with its own budget, seven years after the NPC was founded, Freedman found himself looking for outside funding, such as grants from trade associations, to support the NPC.

Staffing the NPC at the outset was not difficult. Freedman had instinctively hired people like himself—innovators and mavericks—so he already had five or six people in place when the NPC was created. Subsequently, staffing consisted of "picking up some orphans": finding the "parents" of ideas that had been shelved for one reason or another. This is similar to one of the approaches adopted at General Electric Medical Systems Group, where innovations were based on adoption of a task suggested or tried by an earlier manager who had been blocked, had lost interest, or had been transferred (Kanter 1983).

By 1989, the NPC operated as a discretionary expense center on a $3.1 million budget.

The director of the NPC reported to the head of strategic planning and met annually with the president of Raytheon to present the NPC's budget proposal for the upcoming year. Most of its funding came from corporate sources, but it also received support from some divisions (e.g., Laser Products) for specific development work, and the center raised funds through revenues for licensing.

The NPC developed for 10 years without significant change. In 1984, Freedman began talking about his retirement (which took place in February 1987). In the summer of 1986, the subject of a change of management was raised for the first time. The NPC also moved from Waltham to a new facility in Burlington in this period (see Exhibit 2), and a group executive-vice-president was appointed to coordinate the efforts of Raytheon's appliance companies and develop strategies to increase their competitiveness.

In late 1986, Robert Bowen became the director of the NPC. He had been with Raytheon for over 30 years and had been part of the NPC from the beginning, acting as manager of technology transfer under Freedman. Immediately following Freedman's retirement, Bowen and Wes Teich took on joint responsibility for the NPC with another old hand, who soon retired, leaving Bowen in charge. Like Freedman, Robert Bowen was a would-be entrepreneur who stayed at Raytheon only because of the NPC. Bowen emphasized communication and mainstream integration. He saw his job as making sure that the vice president of Strategic Planning had no surprises.

Under Bowen, interaction with Raytheon businesses increased; for example, he sent staff into the divisions on "sales" calls so that they could gain familiarity with the mainstream lines of business.

EXHIBIT 2

A Tour of the New Products Center, 1988

In the heart of an industrial park in Burlington, MA, stood a single-story 28,000-square-foot building dedicated to innovation and creativity. The opening of the new facility in 1986 to house Raytheon's NPC marked both the culmination of NPC founder George Freedman's 44-year career with Raytheon, and his 18 years nurturing and championing the NPC. Since its creation in 1969, the NPC moved from a pair of trailers to modest office and lab space in Waltham, MA in 1970, and finally to the new Burlington facility in 1986, a building specifically designed to house the NPC.

The NPC was part laboratory and part corporate showcase. Engineers and secretaries alike were accustomed to looking up from their work and seeing a delegation from a Raytheon division or customer group touring the facility. In the lobby, mauve couches line two walls of the reception area; in front of them sat a large crimson table and coordinating floral arrangement. The walls, carpets, and reception desk were all coordinating shades of gray. On the left, in an office where meetings with clients were held, the walls were covered with framed advertisements of successful products that originated within the NPC. Leading back from the lobby were a string of offices, all containing stylish black furniture: the offices were both functional and fashionable. Computer workstations sat on the desks; purchased and leased artwork graced the walls; and all offices had glass interior walls.

A broad doorway from the administration area led into the main conference room, which doubled as a functional work area and a shrine to the NPC's successes. Two alcoves abutted the main conference area. The first of these contained plaques commemorating each of the patents earned by NPC engineers. The other contained special industry awards that

EXHIBIT 2 *Continued*

the NPC won over the years. The room was equipped with a projection room and a long table seating 14. The room connected with the NPC's test kitchen, and acted as a corridor between the administration area and the engineering labs.

Beyond the administration area lay the engineers' offices, which were a series of large cubicles in a sunny and spacious part of the building. Each cubicle had a different size and shape. The engineers were given small budgets with which to decorate their own spaces, making each office a custom-designed workspace. Rooms were not numbered at the NPC's Burlington facility; the 35 employees move about easily and the individual touches adequately identify workspaces. The flow of people throughout the building suggested that doors were merely a means of ensuring quiet during meetings.

From the engineer's area, the tour led to the technicians' bench area. The bench area is both spacious and well-organized, even though the NPC worked on as many as 60 projects at a time. Tour leaders make a particular point of introducing visitors to the technicians, who explain their work on a particular project. The technicians have smaller cubicles, less luxurious than the engineers', but comfortable places nonetheless for them to retreat for small meetings or individual work.

Within the ring created by the administration area, engineers' offices, and bench area were a variety of larger rooms where larger projects were underway. These range from a project to develop improved insulation for refrigerators, to a more intensive x-ray, to a piece of emulsifying equipment being prepared for a local teaching hospital. Another room contained a complete machine shop with metal, plastic, and woodworking capability, where, according to George Freedman, "anything can be made." Adjacent to it was a room that accommodated the drafters. There was also a company library, which had the latest issues of *Good Housekeeping, Adhesives Age,* and at least 60 other trade-related periodicals. There was also a terminal designed for access to a technical data bank.

The tour ended in a large well-appointed test kitchen that led into the main conference room. A wide variety of experimental appliances were installed as part of a fully operational kitchen. Designers' sketches on the wall illustrated the aesthetic commitment the NPC offered to its clients. Designers developed the sketches, which showed how new appliances can be integrated into a typical kitchen. The NPC also employed a home economist who interacted with clients and engineers to develop new inventions, and tested many of the smaller products, such as microwave cookware and packaging, in the lab that looked like a kitchen.

Organization

During the study period, the NPC had three loosely defined departments and about 35 people. The first was the new concepts group, considered the "real" inventors and experts in their fields. The second group was composed of product engineers, who were also very innovative, and who turned the concepts into physical models that the clients could see and touch. Like the inventors, they tended to be generalists, but they were more adept at interacting with the people at the client's company. The third group was the specialized microelectronics and computer group. Because almost all appliances used controls that were increasingly computer-driven, the NPC maintained its own computer specialists. Indeed, new products sometimes came from redesigning old appliances with modern controls, like substituting plastic cards with magnetic strips for coin mechanisms in washers and dryers.

Everyone at NPC working in an engineering capacity met formally twice a month (informal interaction occurred continuously) to review the progress made on various projects and to prioritize work depending on client needs and the probability for success. At any one time, the NPC would be working on over 60 new product programs at various stages. By the end of 1989, the NPC had successfully shepherded over 100 new products through the early development phase; they went into production at a rate of approximately two per year, becoming parts of the product lines of eight of Raytheon's businesses.

The ideas for development programs came from three sources:

- About 30% from a request from a client. The client would have done a lot of preliminary work and would have a strong concept of what was being asked for. These requests enjoyed virtually total success (in terms of being developed further by the client).
- About 25% from more general requests for technical help. These requests, in other industries, might be handled by a technology center.
- About 45% of product ideas were internally generated. As long as the allocation of funds to "pure" innovation was not unreasonable, it was permitted. About one-third of the product ideas generated in this manner were accepted by a client.

Progressing from idea creation to a prototype was an *iterative process,* with constant involvement from the client marketing and manufacturing people. Marketing people determined whether there would be a market for the new product with expected opportunities, whereas manufacturing concerns revolved around the ability to make the product profitably with given constraints. It was often said by NPC staff that making a product was the difficult part—innovation came easily. The NPC's task was selling the idea to the client, convincing the client to take the risk, and then getting both manufacturing and marketing managers on board—"to get them to adopt another child."

Equally difficult was maintaining a balance between the "creators" who loved to tinker endlessly with a concept, and the "doers," who were motivated by taking a concept from the conceptual stage to the point where it could be turned over to the client. The popular phrase, "to shoot the engineer," described the occasional need to pry a project away from its creator in order to expedite development rather than perfecting the minute details. The NPC's responsibility usually ended once a prototype had been delivered to the client. It was then the client's responsibility to manufacture and market the product. This practice of transfer and hands-off after the development stage was designed to meet the different management and investment requirements at later points in the entrepreneurial process, similar to the way in which IBM reintegrated developments from its Independent Business units into mainstream divisions (Alterowitz 1989). Because of the close working relationship with the mainstream throughout the process, hands-off was much smoother than in situations in which the corporate entrepreneurs were isolated (Kanter 1988).

A key to NPC's success in converting ideas to products was getting the clients to believe that they invented the new product. Ideas generated solely within the NPC were less likely to succeed than those with a champion for a new product concept in the mainstream client unit. If a product was based on a perception of need identified solely within the NPC, then NPC managers had to devote a great deal of effort to selling the idea. Nevertheless, the NPC still had to expend a portion of its effort in selling ideas to the clients.

There was wide agreement among NPC staff and the strategic planning office to which it reported about time allocation at the NPC during the study period:

EXHIBIT 3

How a New Products Center Should Operate

1. The Goal

There can be only one goal: to aid the company's growth and profit. It does this by developing new products for selected profit centers within the company. These new products are worthless if they do not generate increased revenues and profits—no matter how brilliant the concepts involved. Thus, success is not based on published papers, patents, or just work that was "fun." The criterion of success can only be the number of new products that enter the marketplace successfully. If they do not enter the marketplace and make money, they do not succeed.

2. The Ingredients

The first required ingredient for a new products center is the right people; the second is the right environment. There should be creative engineers whose talents for invention are reinforced by an atmosphere designed for that purpose (as a new products center is).

These people should include generalists who are capable of and stimulated by working in a variety of fields simultaneously. Raytheon's NPC generalists were trained as mechanical and electrical engineers, physicists, materials engineers, and the like, but they cross each other's boundaries with ease.

Then there are the specialists, people who confront unique problems as only specialists can. At the NPC, there are computer experts who design the electronic controls for the products that the generalists develop. Another specialist group is the materials engineers. Everything we sell is made of materials, except software: if the product fails in the field it is usually because materials have fatigued, fractured, or corroded. Too many companies neglect materials innovation as a way to achieve radically new products. At Raytheon, we have tried to rectify that oversight—and it has stood us in good stead.

Finally, there is the product engineering group. Their task and specialty is product transfer to the client after successful models have been demonstrated. They understand tooling, manufacturing, and costs much better than the new concepts group does. Furthermore, client manufacturing managers prefer to work with clients.

3. Relationships with Clients

This is the make-or-break issue. Success can come only with the establishment of effective channels of communication, leading to an accumulation by the NPC staff of understanding of all elements of client businesses. It also requires mutual trust. This can take years to achieve, and once done, it may have to be done all over again when personnel change. The point is, the new products center must become part of each client's team—as though the NPC staff were employees of the client, with the same loyalties.

Since every relationship is based on a different culture, a new products center must give much of its energy to developing sympathy with and sensitivity to them. Only then will there be real agreement on which market area to challenge, which product to develop, the scale of the company's investment, the role of each person in each group, the credit to be assigned to individuals, or the fanfare and publicity that will attend to that credit.

Source: George Freedman, *Management Review*, December 1986.

- **80%** on only what the NPC understood the clients wanted them to do.
- **15%** responding to the "fire drills": because of NPC specialties and technical knowledge they could help clients solve ongoing problems, particularly in production. This was not part of the NPC charter but it made political and organizational sense for the NPC to do it.
- **5%** for ideas generated at the NPC. NPC managers had to approve of the idea—the clients had not identified the need but there was the outside chance that something would come along that would interest the client.

This last category of time allocation was justified by NPC's immersion in both the marketplace and the technologies, as described below. Sometimes, the appliance companies would not have identified a need because they were unaware that one existed or that a practical solution to a problem could be developed.

Sources of new product ideas were diverse. Some came from the military side of Raytheon, which sought commercial applications for new technologies. Other ideas came from listening to television ads, reading trade magazines, going to trade shows, or simply creative genius. Brainstorming was another idea source. Outside experts in relevant fields were on call. In addition to consulting with mainstream businesses to determine their specific needs, NPC engineers and technicians kept in close contact with their counterparts in the client companies in order to keep up with their technological advances. NPC staff were expected to understand the entire business development spectrum from market sensitivity to the business needs of the receiving units. While "autonomous" in one sense, they were far from isolated. Staff traveled widely, visitors to the NPC were common, and at one point the NPC communicated with the receiving businesses by frequent videotapes.

Managing and Motivating Creative People

Freedman was considered the quintessential representative of the NPC, serving as director through 1986. He often said that the best inventors are totally without principle because they steal ideas wherever they see them; his willingness to break corporate rules to get results was a demonstration of this.

Freedman was known to be good at picking the "right" people (important in entrepreneurial projects)—(Alterowitz 1989), selecting for enthusiasm for doing new things as well as a sense of humor. But, as important as technical competence was, good communication skills were even more essential for the "salesmanship" and inter-Raytheon diplomacy that the NPC process required. The NPC's 35 engineers, technicians, and administrative staff members were thus a small, self-selected group, especially when compared with the 77,000 employed by Raytheon as a whole.

The NPC enjoyed a very low turnover rate: of the six people who started the Center in 1969, for example, four remained in 1989. Of those employees who departed over the years, the most notable was the big group that developed the industrial microwave business unit out of NPC roots. No one had ever left for a rival company. A few people had left to start their own businesses, a few retired, but for the most part people stayed at the NPC.

What was behind this success at retaining people? The answer to this question may lie in the make-up of the employees. They were variously described as people who are nonconformists, generalists, very versatile, who did not like to work normal hours or follow set procedures, and were often "difficult to manage."

The NPC's management philosophy, however, succeeded in producing creativity on

demand. There was an emphasis on giving staff every possible ego boost. The directors fought for financial recognitions in the form of bonuses and stock options, but these were token awards (e.g., a $500 patent bonus) compared with the lucrative financial deals other companies were pressed to offer their internal entrepreneurs. NPC people were advertised outside the NPC as bright "hotshot" types. Publicity was used often to boost people's reputations—a key motivational tool (Kanter 1989c). Articles about NPC products and patent awards were posted throughout the NPC building.

The NPC represented for many an escape from the more bureaucratic structures in Raytheon's research and development facilities. At the NPC, the engineers worked on up to four or five projects at once, usually rotating among them at will. Specific definition of tasks and deadlines made it possible to produce innovation reliably, though creative breakthroughs were still serendipitous. When scheduling became tight, it was occasionally necessary to drag an engineer away from a project because s/he was obsessed with perfecting the device assigned to another one. A mild renegade spirit existed at the NPC, a spirit that sometimes did not fit precisely with the Raytheon system.

TYPES OF NEWSTREAM SUCCESSES

There were three principal ways that the NPC contributed to new ventures and new revenue streams for Raytheon. Each involved a different kind of relationship between the NPC and the rest of the corporation.

New Products to Serve Mainstream Client Needs

Most of the NPC's activity fell into this category. The following example is typical. A vice president of Amana came to the NPC with a specific request. Amana was the largest producer of microwave ovens, but competition was increasing. The vice president wanted the NPC to create a free item to go with its ovens, replacing a small trivet then used as a give-away. NPC engineers worked on and developed a coffee brewer, but its impact on sales was not impressive. They switched their efforts to designing a microwave popcorn maker. Designing a popper that would heat every kernel evenly was a formidable task. It took the NPC 10 months and 12 separate patents to perfect it. Raytheon had licensed six other companies to produce it. By the time the promotion was over, Amana had given away more than a million popcorn makers and microwave sales had increased 10%.

NPC-Generated New Ventures

A second type of newstream success was much less common but had larger dollar impact: the development of a new business out of ideas generated by the NPC. Industrial microwaving was the best example.

The development of the microwave oven was closely linked to the workings of the NPC. Microwave technology for military applications of radar was pioneered at Raytheon in the 1940s and '50s. Later, much of this research was funded by NASA. Raytheon and NASA scientists worked toward the development of microwave-powered helicopters and trains, linear accelerators, and platforms in space that would convert solar energy to microwaves and beam the energy back to earth.

Because of the NPC, Raytheon became the dominant force in the market for large industrial microwaves. The business started after an NPC member was visiting a Hormel

meat processing plant and noticed a room full of 100-pound boxes of frozen meat. The meat had been shipped frozen from Australia and had to thaw before it could be processed into hamburger patties. Not only did the process take five days, but the floors were covered with blood. The 100-pound block of meat became 97 pounds, valuable protein was lost through blood loss, and expensive pollution controls had to be installed to deal with the blood. Furthermore, a potentially unhealthy condition was created as the meat hung and thawed.

The NPC engineer immediately saw that all the costs and problems associated with thawing 100-pound blocks of meat could be solved with microwave technology. A group of engineers went on to develop large microwave ovens for the meatpacking industry that could thaw those same blocks of meat in 30 minutes instead of five days with zero blood-drip loss. Eventually, large ovens were in virtually every meat processing plant in the country. Other uses for industrial microwave include pre-cooking bacon for fast-food restaurants, and curing rubber products like huge tires for earth-moving machines. From the small group of engineers who were originally part of the NPC, the Industrial Products Group, which makes these microwave products, became a separate operation accounting for $10 million in annual sales by 1988 and employing 50 people.

Technology Leverage and Cross-Fertilization

The NPC also contributed to Raytheon in the related areas of technical leverage and licensing revenues. Some of the NPC's technical products had significant leverage effects on other company businesses regardless of modest dollar volume. For example, a new magnet material developed by the NPC was first announced in 1970 as "the world's most powerful magnet." Although it never exceeded $1 million in annual sales, it gave Raytheon an advantage over its competitors when it was first incorporated into traveling-wave tubes. Eventually, put into an electronic component in missiles, the magnets had a major impact on the company's largest segment, its missile systems business (Freedman 1986).

Other products that were developed at the NPC but rejected by the client, or which otherwise did not fit into the company's businesses, were licensed for use outside the company. Originally, the NPC was told by superiors not to get into licensing. Yet the NPC did so anyway, "working undercover for three years," as a staff member put it, until eventually it was discovered and officially approved because there was so much money coming in. By 1988, annual licensing revenues amounted to about $1 million (the equivalent of the pre-tax profits of a typical Raytheon $10 million business). The NPC generally assigned the rights to the licensing revenues to the mainstream organization whose projects stimulated the development of the product.

In addition to its role in developing newstreams for mainstream businesses, the NPC also facilitated internal technology transfer. This was possible because of its independent role, straddling or bridging several businesses. For example, NPC received funding from the Laser division to develop several products that allowed the group to achieve major competitive advances. The NPC could subsequently apply what was learned about laser technology to work being done at Amana, Caloric, or Speed Queen, where familiarity with laser technology was absent. It was widely believed that the innovation process could be stimulated by seemingly random connections between projects that might become important breakthroughs (Kanter 1983, 1988).

The process also worked in reverse. For example, when the NPC was working to reduce the level of vibration in a refrigerator, they called in assistance from engineers in another division who worked on vibration problems in a missile system. If outside expertise

was needed, there were 50 Raytheon plants within a half-hour drive of Boston. Thus, a group of 35 people could draw on thousands of experts and make connections across businesses.

The NPC's View of Factors in Its Success

Whether the product was one that has been specifically requested by a client or developed from within the NPC, the NPC staff believed that certain factors made it more likely that the product would be successfully developed (Freedman 1986, 1988).

- *A "receiving" mainstream champion is needed.* Someone in the client organization who enthusiastically supports the development and devotes a significant amount of time selling it within his or her own organization is invaluable. If a Raytheon division isn't interested in the new product or doesn't want to manufacture it, the idea will probably be dropped.
- *The client should become involved in the development process at an early stage.* If the division's manufacturing people can have input toward the design, and their marketing people can give advice on the aesthetics before the product gets too far along, they are much more likely to support its development.
- *The product should become tangible as early as possible.* The people at the client organization want be able to see and touch the product in the prototype stage. If the computer control that runs the appliance has not yet been incorporated into the product itself, then the NPC people know that it should be hidden under the table during the product demonstration so the client does not get the incorrect impression that the new product comes with a bulky control box sitting on top of it. "You have to do a lot of that with clients," one project manager observed. "Give them a prototype which looks pretty much like it would in the real world, otherwise they get hung up on the cosmetic details and don't see what the new product concept is really about."
- *The product must be priced right.* When tinkering with new technology and product ideas, it is easy to get carried away. Because the NPC supports the consumer appliance businesses at Raytheon, the technology and the new ideas have to be affordable.
- *The clients should be made to believe that they invented the product.*
- *The client's design engineers and R&D people who have the biggest "not invented here" problems should be kept out of the picture.*

RESULTS

The more than 50 successful new products and businesses developed over a 15-year period resulted in over $300 million in incremental sales and licensing revenues during the 1980s—all for an initial investment of under $20 million. Despite the high percentage return, however, in absolute terms the NPC was only a very small part of Raytheon. In a company the size of Raytheon, a facility with a $3.1 million budget and fewer than 40 employees could be easy to miss. Nevertheless, the NPC tried to maintain a high profile. The NPC's existence was justified by the flow of products through its doors. The threat lay in the danger of being perceived to be in competition with the traditional R&D structures, even though NPC administrators have successfully positioned the Center as a supplement to, not a replacement

for, "traditional" R&D channels. On the other hand, since the NPC was funded by the corporation and not the individual divisions, and since it was so small, it was less likely that its budget would be cut during business downturns. Thus, the NPC deliberately stayed small.

The large size of Raytheon made it easy to insulate the NPC from the rest of the company when appropriate. In the area of human resource management, the environment of the NPC made it an attractive workplace for individuals who might otherwise chafe under the more bureaucratic structures in the rest of the company, particularly the military contracting side. Whereas the NPC was subject to the reward structure of the entire company, NPC leaders fought successfully to secure compensation and bonuses for the staff.

The funding structure was particularly critical to the NPC success. The NPC was part of an entrepreneurial process with minimal risk. First, the investment in the NPC itself was exceedingly modest. Then, once products were designed, subsequent financial risk was mitigated by leaving the development decisions in the hands of the client companies. The NPC was neither budgeted for nor had to concern itself with the funds necessary to take a newly developed product from the laboratory to the marketplace. Whereas NPC personnel were consulted during the process that followed the departure of the product from its auspices, additional responsibility was assumed by the mainstream businesses. This clear delineation of development and production permitted the NPC to concern itself with purely developmental issues. Since the client companies were involved with the process throughout and made the final go/no-go decisions, the success rate of development ideas was boosted.

As in any innovation process, there were failures in the NPC portfolio. Some ideas may be killed before they have reached the production stage. The most common causes of idea death were:

- *A product that would be too expensive to produce,* such as a clothes dryer that saved energy by dehumidifying clothes in an air-conditioning cycle rather than by heating them.
- *A technical imperfection,* such as a heating unit built to fit inside a fireplace, which fell apart after a year because of a corrosive gas it gave off internally.
- *The departure of a key player,* particularly the champion, from a client organization.

Other failures stemmed from unexpected events and environmental shifts occurring in the middle of the development process (see Kanter 1988, for a discussion of the vulnerability of "middle" period). Although not a failure in technical terms, the NPC's cook-by-weight microwave oven, an effort to create "one-touch cooking," was perceived as a failure because it performed below expectations. Items to be cooked were placed on a built-in scale, and a computer control would determine the proper cooking time automatically. The idea had come from the interaction between the NPC and the Industrial Microwave Division; to heat large blocks of frozen meat required cooking times based on weight. In a meeting to discuss industrial microwaves, someone asked whether or not the same concept could be applied to home use if a scale could be built into home microwave ovens. The idea was a good one, but the timing was bad. Designing the scale and computer controls took longer than expected. One of the reasons for the delay was an accident that occurred when the oven and its then-separate computer control was being field tested at the home of an engineer. The engineer's cat apparently liked the heat that the computer control generated, so it spent hours lying on top of it. One day the cat got violently ill—into the computer—and destroyed several months' worth of work and components costing $64,000. Even if the cat had not delayed the project, the market timing simply would not have worked out. Amana was introducing this expensive,

top-of-the-line oven just as the Japanese and Koreans were hitting the market with low-priced models. The opportunity was lost, and instead of becoming a big seller, the cook-by-weight oven was only a marginal success, with sales of only about 1500 units a year.

Overall, development successes far outnumbered failures. The NPC had an enviable track record as an entrepreneurial vehicle.

THE NEW PRODUCTS CENTER AS AN ENTREPRENEURIAL VEHICLE: ISSUES IN PERSPECTIVE

The NPC was successful at managing many of the paradoxes of entrepreneurship in established companies. The NPC had many of the elements often found to be associated with the creativity and idea—generation phases of innovation (Amabile 1988; Kanter 1988) along with excellent links to the mainstream businesses to ensure further investment in the NPC's creative outputs. The NPC was small enough to allow technical specialists to exchange ideas freely and to stimulate each other's creativity. Its staff was loosely managed and encouraged to work on several projects at a time, allowing discoveries and insights from one project to be applied to other projects. As a corporate entity that was centrally funded, the NPC had the independence to work in the most promising areas and to work through the appliance divisions, getting to know their businesses, their markets, and their resources. Not being part of any one division, the NPC also brought a fresh point of view to any project while having immunity from the daily problems of that division. At the same time, it maintained close working relationships with the established businesses, thus supporting their needs.

Because the NPC's responsibility ended when it handed over a working prototype to a division, its staff had the relative luxury of being the blue-sky conceptualizers without the responsibility for actually manufacturing and marketing the product—and without threatening the incumbents in the mainstream businesses.

It is a truism of entrepreneurship research that entrepreneurship requires "patient money." So does an entrepreneurship *program*. By beginning modestly and peripherally, with low expectations and shoestring funding but a protective sponsor, the NPC could take the time to experiment with its own organization and operations. It would wait to become visible until it found the appropriate balance between independence and integration and developed a track record. The track record of success would then create legitimacy and widespread support, reducing its dependence on a single sponsor. Whereas much of the popularized literature on innovation has stressed the single sponsor to back up a single product champion, innovation efforts are more likely to be sustained when they have multiple sponsors at many levels of management (Schroeder et al. 1989, pp. 129–130).

Whereas the program was too peripheral to be a threat or to face unmeetable expectations for performance, the long period of development of the NPC concept allowed it to gradually gain acceptance by the mainstream. In contrast, some of the new venture or innovation groups in other companies began with great fanfare and were cancelled within a *shorter* time frame than it took for the NPC to find its ultimate niche. The Eastman Kodak program, for example, promised much greater payoff to the company than the Raytheon NPC, as it was undertaken on a much larger scale and attempted to build stand-alone new businesses; but it also sank faster, with greater losses. Other programs hope to be role models for "transferring the corporate culture" but then forget to serve the businesses, generating political battles, jealousies, and tensions that result in program elimination.

The Raytheon NPC began as a "skunkworks" (Peters and Waterman 1982) in an almost literal sense, as it was founded by a maverick with bootlegged funds and staffed with people

who could not fit into the mainstream company. But from the beginning the NPC signaled its intention to be useful to the mainstream, not opposed to it. By concentrating on new opportunities for existing businesses and the use of latent Raytheon technology and expertise, the NPC avoided the diversification trap—a tendency to equate business revitalization (and thus acquisition and entrepreneurship) with moving *away* from the company's areas of competence (Biggadike 1979).

The NPC was small in size but not self-contained. It was clearly *not* a "reservation" that had to exist in isolation in order to remain creative (Galbraith 1982); its creativity derived not only from staffing and internal management of NPC activities, but also from its very linkages with the Raytheon mainstream. It drew technological resources from all over Raytheon, including R&D groups in client organizations and hundreds of engineers on large defense projects. It stayed closely linked with the mainstream operations that would receive and exploit its new ventures, referring to them as "clients." It applied technology from one area to another, helping to build synergies by serving as a bridge between the businesses it served.

Overall, it was too small to be a threat, and too integrated to become peripheral or irrelevant.

The Raytheon NPC, in short, had modest goals: new products for existing businesses. It did not seek to generate enormous financial returns, to transform the corporate culture, or to "save" mature businesses by finding large new markets. But the new products it developed have become successful lines equivalent to new ventures, spawning at least one stand-alone new business unit, and the licensing revenues it earns are substantial.

Thus, the paradox of entrepreneurship in established companies *can* be resolved. Innovation can be routinized. Mainstream and newstream can be linked. Indeed, one can conclude from the Raytheon NPC case that the success of a new venture program depends on just such linking. If successful entrepreneurship is a matter of "coordinating independence" (Kao 1989), then successful corporate entrepreneurship derives from stressing the coordination even more than the independence.

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