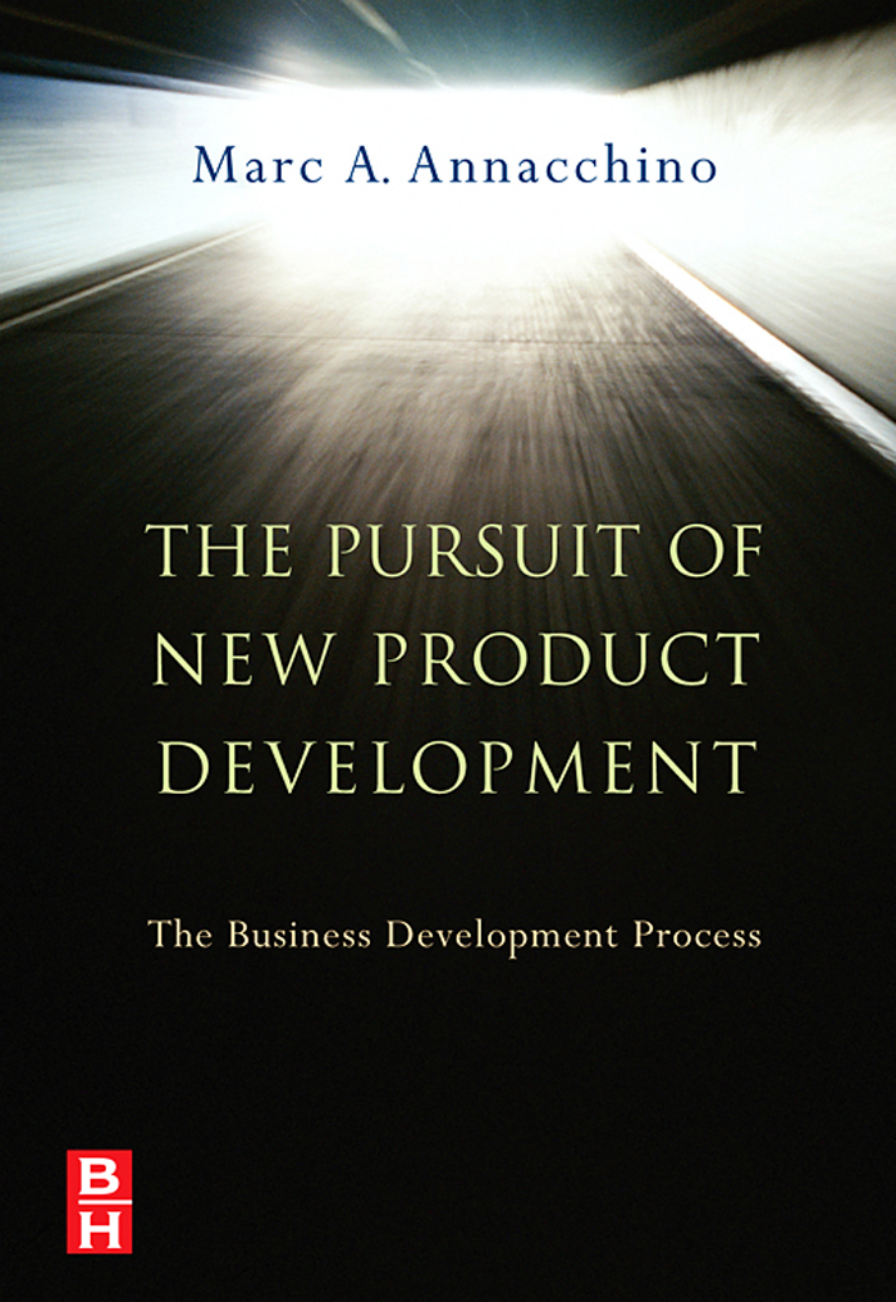
Marc A. Annacchino
THE PURSUIT OF NEW PRODUCT DEVELOPMENT
The Business Development Process
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The Business Development Process

Marc A. Annacchino, P.E.

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To Terrie, with whom I share the future,
To Angel Ashley and Alecia who are our future
To my Mother and Father who taught me how to embrace the future.

And

Also to the men, women, and families of the
United States Armed Forces
who work every day to
secure our future.

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PREFACE

WORLD COMPETITIVENESS AND LIFELONG LEARNING

The Objective of this Book

The objective of this book is to provide the reader with a thorough understanding of the business development process and how to execute a product development program to grow the business.

This book serves to outline the complexities in the planning, execution, timing, and problem solving skills required to manage a program. We are in a fast changing world where change brings adversity as well as opportunity. We all must practice continued learning to be world competitive, which allows us to participate in these new opportunities.

The Evolution of Employee

The learning process, as we all know, takes place every day during our life. More formalized learning occurring during school gives way to updates, seminars, and possibly more formal training. The first positions out of school allow us to gain experience. As we work longer we begin to amass more experience.

Initially, when we enter the workforce, we are on a quest for experience. This cements our learning. As we work longer, the many experiences both positive and negative shape our opinions and judgment. At some point in our career we reach a point where opinions are solidified.

There is a fine line between extensive experience and preconceived notions. If we are not careful, we cross the line into jaded thinking. A balance must be established.

The marketplace reestablishes the reference each day, forcing us to cope with the realities of energy level, absorption of information, and desire. Each day we can choose to reinforce and harden our own paradigms, or open our minds to new learning. The new learning allows us to remain on top of our game and be a formidable gladiator in the arena of business.

The Evolution of Firm, Corporation, Company, and Industry

The firm goes through a parallel process as it matures: Initially the young entrepreneurial organization meets the market head on with energy and intellect and drive. The corporation, as a unit, is intimate with the marketplace and is an active member of the business. Initial success allows the corporation to grow and expand.

With continued growth comes organizations, structure and corporate momentum. Left unmanaged, bureaucracy begins to set in. Lack of customer intimacy may begin to affect orders and ability to secure orders. Not affected by any one item, the lack of progress on the following perspectives contributes to a loss in world competitiveness.

- The march along the pathway to intellectual competitiveness
- Absorption of external information
- Ability to synthesize solutions
- Ability to analyze situations objectively and form perspectives outside the organization
- New talent mentoring
- Arenas and industry segment activity
- Functional displacement of products and processes
- Leadership's role
- Diffusion index of new information
- Assimilation index

To prevent, or even reverse the natural evolutionary process, the corporation, by virtue of its employees, must take personal responsibility for remaining world competitive by lifelong learning. This book's intent is to provide a basis for that learning.

Marc A. Annacchino

C H A P T E R 1

THE BUSINESS OBJECTIVE

BACKGROUND

1. New Product Development and the Economy

New product development is an integral part of a healthy, growing economy. This chapter will start out with a review of the various means for economic development, including manufacturing and how product development plays a role. The various types of product development and how they draw on and pay out to the economy are also included. In addition, we will look at our world and what it would be like without some famous new product developments. Finally, there is a review of what happens to a company without new product development, from a purely financial perspective.

A. Economic development

New product development contributes to the economy by generating revenue and profits to a corporation that otherwise would not have been generated. The revenue then is paid out to vendors (other manufacturers). The vendors themselves pay out to their sub-vendors and personnel, or retain the earnings. Salaries are paid to personnel and they, in turn, spend funds to purchase goods and services from other profit-making enterprises. The retained earnings fund the long-term growth of the enterprise and increase the value of the business. The profits are taxed and that goes into the pool of funds to govern the community and provide for the common good.

This is the role that private investment plays in the economic development arena. The public sector contributes to the economic development by providing incentives to encourage manufacturers to establish their businesses in their locale. They provide the means for funding business expansion and growth. A collateral activity is to network with other manufacturers on your behalf for future business. Figure 1-1 illustrates the typical funds flow in a manufacturing enterprise. As will be seen later, the service sector of the economy has a funds flow that is different from that in manufacturing.

Service businesses are not characterized by the leverage associated with manufacturers. Instead, they are characterized by a smaller investment in capital equipment, a smaller investment in each revenue cycle, and a generally faster revenue cycle; as such, they generate incremental profits from incremental investment with low fixed costs. This is shown in Figure 1-2.

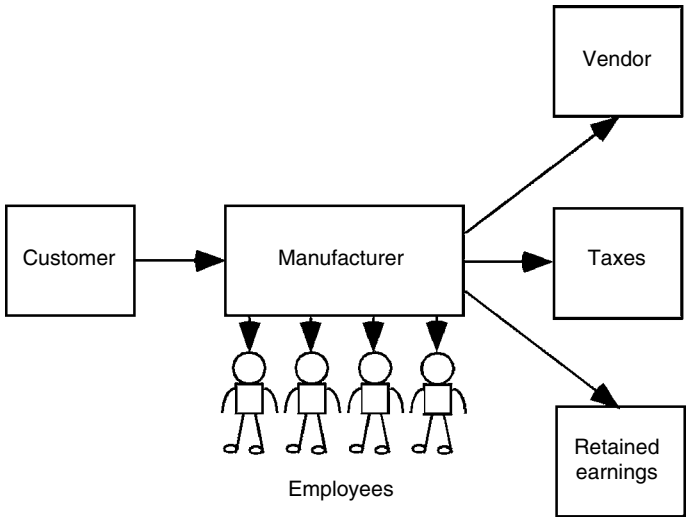

Figure 1-1. Manufacturer's funds flow model.

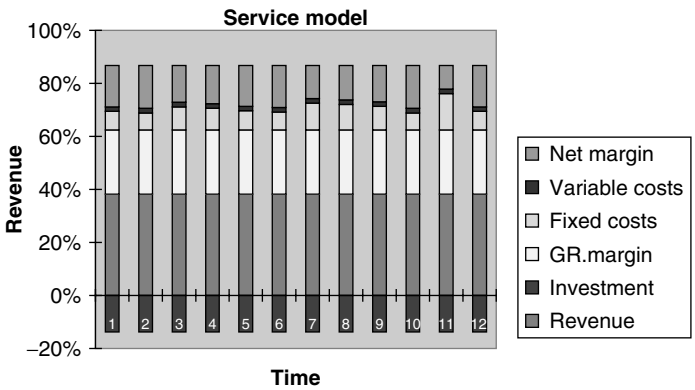

Figure 1-2. Service business funds flow model.

As shown, the service model has relatively constant net profit. This is because there is no major initial investment to absorb and there is a small incremental investment with each order. The other costs are somewhat variable and track with the incoming order rate. Incremental profits can track with incremental revenues. Service businesses generally have a lower barrier to entry than do their manufacturing counterparts.

Manufacturing businesses differ markedly from service businesses in that leverage can occur. This leverage is characterized by larger returns for their investment. A larger investment is required at the outset, but revenue is generated through a stream of returns from year to year through the products' life cycles. This assumes there is sufficient volume to offset the fixed expenses and the absorption of the initial investment. There is significant investment in capital equipment and processes, along with significant payoff if you have hit on the right opportunity with the right product.

The manufacturing financial model (Figure 1-3) shows that net margin increases at a disproportionate rate as revenue increases. This is because the fixed costs are already absorbed

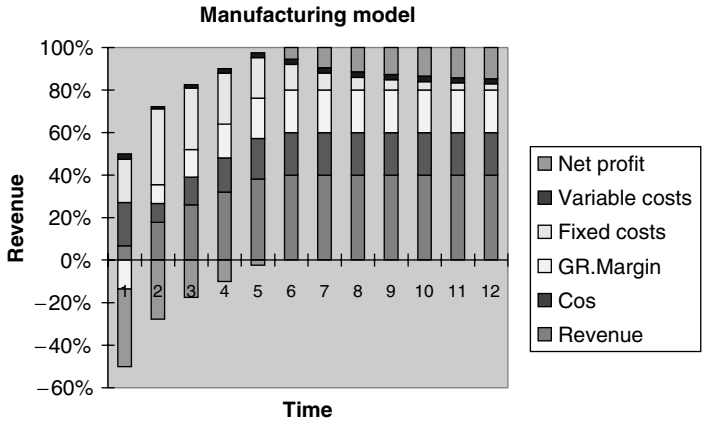

Figure 1-3. Manufacturing financial model.

by some base level of business and the incremental revenue does not require incremental investment with each order. Fixed costs decrease as a percent with increasing revenue.

However, there is a large initial investment to design the product, which can run the length of the diagram in time. Figure 1-4 illustrates how a manufacturing enterprise's funds flow as a result of new product development.

An idea is conceived and qualified in terms of opportunity and overall business sense. There are costs associated with these activities, such as market planning costs, surveys, customer visits, and demographics data analysis. There are also costs in taking the opportunity and the market data fed back and coalescing them into a product opportunity. The scope of the target market is accounted for in this stage, and the product platform must be laid out to reach the market at a cost-effective price. These costs are generally low compared to the other costs in the product development arena.

The next phase is the investment and development phase of the program. This phase takes the product concept and creates the intellectual property required to take a concept and reduce it to bills of material, manufacturing processes, and define a manufacturable product that the market will purchase. There are technical, labor, development, tooling, and other capital equipment costs in this phase.

The next phase in the model assumes that all the development is complete and manufacturing takes place. Here, there are set-up costs, material, labor, and overhead costs required to produce the units. The product moves out of manufacturing and into the sales channel for

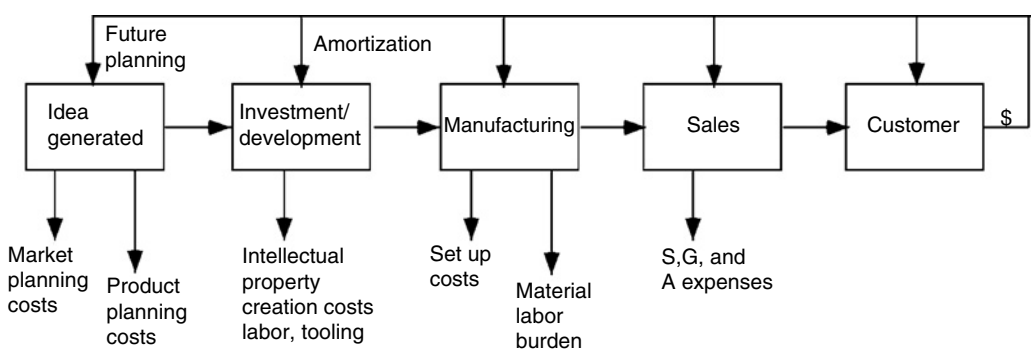

Figure 1-4. Manufacturing funds flow as a result of new product development.

placement at the customer. In this stage there are a host of sales, general, and administrative (SG&A) costs incurred.

Finally, the product is at the customer and funds for the product have changed hands. The manufacturer now can begin to enjoy the profits. These profits come after the funds are distributed appropriately. Dollars must go back to fund the sales expenses, general expenses, and any other expenses previously incurred. Manufacturing must be reimbursed for the materials labor, manufacturing expenses, and inventory carrying costs.

The development of the product must be amortized so as to be able to fund future developments. In addition, funds must also be channeled back to the product planning and market planning function to allow the proper expenditures to verify product viability, market program viability, and future enhancements and products.

B. Types of new product development and their contribution

There is a variety of different types of new product developments in existence today. Each is used for a different reason, and each has its own objectives and dynamics for execution. The following is a common list of the different types and their attributes and contributions.

1. "New to the world" products

These are somewhat revolutionary in the marketplace in that the marketplace never had exposure to the product directly—perhaps only as a concept or prediction from a futurist. They generally create entire new markets that never before existed. An example would be the cellular telephone. Predicted only vaguely by the Dick Tracy cartoon strip and personified as a "communicator" in *Star Trek*, the cellular telephone has revolutionized person-to-person communications in modern-day society. One such product looming on the 10-year horizon today is mass-market fuel cells.

These product development programs generate entire new markets that were not previously there. They enable true growth in the economy by generating revenue to the enterprise. They also have a multiplication effect in the economy by generating requirements for parts and subassemblies that need to be developed and supplied by the vendors. In many cases, they generate new channels of sales and new routes to market.

2. New product lines

These new categories of products allow entry into newer markets not previously participated in by the manufacturer. By adding the categories, manufacturers must be careful to protect the positioning of their existing products, which generate the existing business. Failure to do so will place them in danger of converting loyal customers away from one already successful product to a new one, with no net gain in market share. Perhaps a good example of this type of product would be the Hyundai Azera, a higher-end automobile offering from Hyundai. Here a large manufacturer with many product lines generated an entire new category of car to serve a more discerning customer base. Careful not to jeopardize their existing base, this new car company initially launched its product in the same value-focused dealerships selling the existing products. This is different from the Acura offering distancing itself from Honda.

The new product lines generate incremental revenue to the manufacturer by leveraging the market's familiarity with the manufacturer into new categories of products. In many

cases, the market's familiarity with the manufacturer paves the way for new categories of products. Sometimes these products go into new markets, but can also be an alternative to existing ones.

3. Additions to existing product lines

These efforts support existing product lines by creating line completers to extend the influence of the original products' brand to larger audiences or extending range, power, and scope. All are done in the attempt to secure more of a market. An example of this type of product would be the M&M Candy Company extending their product line to M&M peanut and M&M almond and seasonal M&Ms for Christmas and Easter. Another example would be tomato sauce versions—hearty, traditional, roasted garlic, Alfredo, and vodka tomato. By taking the basic product and modifying it, a wider market share is realized.

The addition to existing lines has a similar effect on the company's revenue as the new product lines. They generate incremental revenue by leveraging the existing product familiarity rather than the company familiarity. These programs generate incremental improvement in the economy, but generally fall short of the contribution made by the totally new products.

4. Improvements and revisions of existing products

As time marches on, customers have higher expectations of your product and the competition adds features to their offering. It becomes necessary to improve your company's offering to increase market share or to retain it. By redesigning the product or repackaging it, your company can offer a greater value or satisfaction to the customer. It is possible to temporarily affect this by enhancing perceived value; however, an ever-more-informed customer base will respond to actual value increased in the long run. An example of this type of product development is the automotive companies adding features to their base models each year as standard.

Generally, the improvements to existing products do not generate additional revenue to speak of. They are simply a means to retain the market share or to slightly improve it. They are defensive in nature and in many cases are stopgap measures until a new product program can be introduced. These programs do little to generate a vitalized economy in the long run, but can provide time and revenue to pursue the development of a replacement.

5. Repositioning

Another means of increasing or maintaining market share is through repositioning. A repositioning is an exercise in changing the perception in the mind of the consumer. It generally can happen with products that are lower in value (dollar amount), or the consumer spends little time evaluating the actual data. For high-dollar decisions, the consumer will generally take the time to evaluate the facts and make his or her own decision. Repositioning is truly a marketing activity rather than a development activity. An example of this is a change of advertising by focusing the audience on a possible linkage drawn between certain brands of cereal and a high-fiber, lower-cancer-risk diet.

Repositioning is another stopgap measure for generating revenue from an existing product. It does not generate overall growth in the economy per se; rather, it is similar to an improvement or a revision except that it doesn't even necessarily require a product change. It simply repositions the product in the mind of the consumer.

6. Cost reductions

These programs are strictly a means for reducing the cost of products to offer similar value. They generally are the result of a competitive initiative, either generated internally or from external forces. In many cases, it is simply a means to generate more volume, which will generate less incremental profit (but perhaps more overall profit). Whatever the motive, a cost reduction is generally meant to increase unit volume through the channel. This becomes easier with capital equipment costs and development costs absorbed, and the manufacturer wants to capitalize on the sales channel.

Cost reductions are helpful to the organization by generating additional margin from the existing product. This margin can absorb development costs and manufacturing set-up costs. In many cases, they enable a period of time to continue with the product, generate the revenue, and allow the organization to position itself with a new product. They do not, however, generate any real growth in the economy.

Figure 1-5 summarizes the different types of product developments in terms of (a) time required to develop (b) the revenue to the economy; (c) the revenue to the company; (d) the company's positioning; and (d) the margin impact.

C. Narrative and financial review of a nondeveloper contribution

Figure 1-6 illustrates the dynamics of the income statement of a company that has little new product development. As shown in the financial analysis, a company can grind to a slow halt by not participating in the dynamics of the ever-changing marketplace.

Along the top are the years under study. Along the left side are the income statement categories. The following summary discusses the perspectives and how they affect the overall operation.

1. Cost of sales

The cost of sales has a natural tendency to increase over time. This is a result of the increases in direct labor costs in manufacturing the unit as well as the effect of vendor increases in pricing. For most manufacturers, the product maintenance function of development has to initiate cost reduction wherever possible, just to stay even. Therefore, to progress down the learning curve, significant initiatives must be made to effect cost reductions because these changes must offset the increases already built-in.

Type of development	Time to introduce	Potential revenue contribution to economy	Revenue contribution to company	Company positioning strategy	Potential margin impact
New to the world	Longest	Highest potential	Highest potential	Market development	Highest
New product lines	Long	High potential	High potential	Market development	High
Add to existing	Medium	Medium potential	Medium potential	Line complete	Medium
Improve or revise	Short	Little potential	Medium potential	Market share	Medium
Repositioning	Shortest	Little potential	Medium potential	Market share	Medium
Cost reductions	Shorter	Little potential	Medium potential	Raise margin	Medium

Figure 1-5. Types of product development programs.

	Base Year ($)	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Year 5 ($)
Net revenue	100,000	101,000	102,000	103,000	104,000	105,000
Material	45,000	45,950	46,400	46,850	47,300	47,750
Labor	10,000	10,600	10,700	10,800	10,900	11,000
Burden	25,000	25,250	25,500	25,750	26,000	26,250
Total cost of sales	80,000	81,800	82,600	83,400	84,200	85,000
Gross profit	20,000	19,200	19,400	19,600	19,800	20,000
Engineering expenses	4,000	4,200	4,410	4,630	4,862	5,105
Administrative expenses	3,500	3,675	3,858	4,051	4,254	4,467
Sales expenses	3,000	3,150	3,307	3,472	3,646	3,828
Total expenses	10,500	11,025	11,576	12,155	12,762	13,401
Net profit	9,500	8,175	7,823	7,444	7,037	6,599
Provision for tax	4,275	3,678	3,520	3,350	3,166	2,969
Net profit after tax	5,225	4,496	4,303	4,094	3,870	3.629
Percent return on sales	5.23	4.45	4.22	3.98	3.72	3.46

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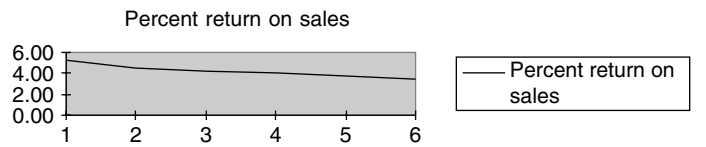

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Figure 1-6. (A) Income statement, nondeveloper; (B) Percent return on sales

2. Profits

Assuming the expenses stay at a constant amount or grow slightly, this increase in materials and labor and manufacturing expenses (burden) creates enormous offsets in the net profit of the company. Salaries and benefit expenses increase with time because the manufacturer must remain competitive with the other, more dynamic companies in the industry. Sales expenses will increase as more concessions, incentives, or travel must be done to achieve the same result from year to year.

3. Strengths

The financial strength of a company degrades with a lack of successful new product development. Unfortunately, the effect is not known immediately. The financial picture initially looks better because the expenditures normally spent on a development are saved. This is, however, a short-term gain, because the market will soon bypass the manufacturer with new products from other firms, leaving the manufacturer with little to sell in the evolved marketplace. In later analysis, the strength of the enterprise diminishes.

4. *Market share*

If the manufacturer cannot keep up with the marketplace's appetite, eventually the package of values it offers does not meet the customers' needs and it begins to lose market share. By losing the revenue from lost market share, a dangerous downward spiral begins that is difficult to reverse.

5. *Response to changes in environment*

If the manufacturer cannot keep up the pace established by its industry by evolving product lines on a normal evolutionary path, it is at great risk from the negative effects of changes in the playing field, or legislation changes, or salient attacks from nontraditional competitors. This weakness will manifest itself as a financial problem over time, which will eventually place limitations on the organization's ability to respond in order to survive.

D. A look at our world without some new product developments

1. *A world without Apollo*

Not all new product development comes from private investment. The U.S. government regularly conducts research in a variety of areas in order to generate understanding, research, and analysis of data. One of the more scrutinized and high-profile development programs in the 1960s was the project to land a man on the moon and safely return him to Earth.

Aside from the sheer magnitude of the program, the raw objective was to develop methods, produce machinery and hardware, and execute a mission to land and return. The task represented enormous technological hurdles in numerous disciplines. The achievement of this objective in July 1969, must be historically underscored by the numerous spin-off technologies that have changed our world.

The Apollo program accelerated the development of technology in an unprecedented manner. The need drove the course of action: If it existed, use it; if it didn't exist, invent it. Time was literally of the essence. Money was no object, and resources were granted on the basis of how much time it would save, not how much it cost.

There were several technologies that experienced accelerated development during that era. The term *accelerated* is the operative one in this case. Most technology eventually gets developed as people become interested in its potential and entrepreneurship drives these elements into society. However, the Apollo program literally rocketed development of certain technologies that would have taken many more years to implement without the driving requirement that necessitated its invention.

Rather than listing and discussing each one, it may be more effective and interesting to look at our technological and societal world without the Apollo program. Let's examine the latter half of the 1990s as we look at "a world without Apollo."

You wake up at 6:00 A.M. The mechanical radio alarm clock clicks on with the local news. The clock is mechanical because a digital alarm clock is too expensive to build out of discrete transistors. The integrated circuit showed a lot of promise in the 1960s as an idea but was never funded, and so its widespread use is just beginning. However, that is not on your mind.

What is on your mind is the temperature outside and the chill you feel inside. There's a 20°F cold snap outside. Back in the 1970s, oil prices skyrocketed, and so Americans living in North America needed to hold down expensive oil and natural gas usage. Your home is insulated with 1960s technology and cannot hold in the heat very well. The less-than-optimal insulation

used is due to lack of funding to develop the new technology in the 1960s. The Apollo program hardware utilized specialized insulation and polymerized film materials, and solved its heat retention and heat rejection problems by the use of advanced insulation systems.

You are a jet aircraft pilot and have to fly to two cities and return home early this evening. You are planning to go to the baseball game tonight to see your favorite team play, so you hope it warms up later in the day, upon your return.

Today, your children are going to perform in the school play and your wife is planning to go food shopping and investigate a new hairstyle at the beauty shop.

You are pressed for time because you forgot to buy movie film to record the kids' school play. You can only film three minutes of the play and have no means for sound recording to coordinate with the movie film. The video camera has not been invented yet. Because there was no need to develop the technology for portable television cameras used on the Apollo missions, there was no spin-off to personal use.

When your wife gets to the food store and is ready to check out, there is a long line at the checkout. Because all groceries are checked out by hand, it takes longer to process the customers. Bar code scanners haven't been invented yet, nor is the raw technology in a cost-effective package for use in the commercial sector because integrated circuitry has not progressed far enough down the learning curve, so she waits.

Now, it's off to the beauty shop to experiment with that new hairstyle. Your wife will be taking a significant risk in experimenting because she will have her hair cut very short for the new hairstyle. In addition, the new style requires a permanent-wave treatment. Both items are a one-way commitment to the new style for two to three months. The image processing technology developed for the Apollo program has not yet been invented, since there was no need. Consequently, no spin-off technology allowed the beauty shops a means for taking your wife's photo and digitizing it to try out different hairstyles before cutting or waving.

Your wife now starts to plan the budget for the next month. Unfortunately, she is calculating and adding bills manually and makes a mistake, allowing more expenses than can be covered by the checking account's current balance. The handheld calculator has not been invented yet. There has been no market need for integrated circuits or cost reductions, so there are no calculators yet. Eventually you will have one as the world progresses into the acceptance and the implementation of these technologies at the normal, nonaccelerated pace.

Meanwhile, you are at the airport and ready to start your day. You climb into the flight deck and see the traditional stick and rudder used to fly the airplane. There are very few avionics and no inertial navigation system. Everything in terms of flying the plane is done by manual calculation. There are no major systems, such as navigation or communications, in place. The Carousel system for inertial navigation and fly-by-wire technology have not been invented or implemented in the fleet of planes yet. There was no requirement for inertial navigation for long distances like in the Apollo program, so it never made its way into the commercial marketplace. This system, combining computer technology, electromechanical physics, precision machining, inertial navigation algorithms, and a worldwide infrastructure, will be available through natural, incremental evolution around the time you plan to retire.

You land in the first city of your journey and listen to the television in the airport terminal. There is a news story about an entire family who perished in a home fire. How sad and tragic, you think, visualizing your own family. This family, like many others, died because the fire consumed them while they were asleep. There was no means for early fire detection or warning; the smoke detector was never invented for home use. The Skylab program in the early 1970s used mostly Apollo hardware, and the National Aeronautics and Space

Administration (NASA) needed a means for early detection of smoke and fire for America's first space station.

Your attention shifts back to the weather, and you are thinking about that game tonight and want to know whether it will be too cold to go. You do not have any way of planning for the weather because modern forecasting methods are limited to predictions only—satellite photos using image enhancement have not yet been invented. There was no requirement for it on Apollo, so no spin-off.

Your children go to the school library to do research for a term paper. They comb through the card catalog and cannot find any article or reference material for their papers. The library's focus has not yet shifted from collection of books to access of information.

Your kids will have to wait for the reference material to be sent through the mail because there is no Internet with universal access yet, no low-cost computers affordable enough for the municipal budget, and no network of other users.

You finish your flights, arrive back home, and plan to go to the game. Your wife asks you to hang a new picture she bought today. You go down in the basement to get your electric drill to drill the hole required for the anchor. Unfortunately, you loaned the extension cord to a neighbor. You have no means for electrical power in the area where you will place the picture—cordless tools have not been invented yet. They will be an eventual spin-off from the drill used to core lunar samples on the Apollo missions. You will have to wait until tomorrow for your neighbor to return the extension cord.

You are off to the game at last. It never did warm up, nor did you ever get any advanced warning. It would be nice on a night unseasonably cold as this to have a cover over the stadium to retain the heat. Traditional roofs over stadiums are expensive and require huge means for support. Lighter, more affordable fabric used in domed roofs for stadiums and airports hasn't been developed yet. (They use spin-off fabric technology from the Apollo Moon suit developed for the astronauts to traverse the lunar surface.) It's so cold in the stadium that you get some hot coffee rather than a cold beer!

This short vignette represents only a few technologies developed for the space program that are in the everyday products we now take for granted. It has been often said that the space program was wasteful in terms of spending the funds on space travel rather than "curing" the problems on Earth. By conservative estimates, there are more than 30,000 products developed and launched as a result of the space program.

The reality of these results are that the tax on profits alone from the revenues generated from these products and technologies have paid for the government's investment in the entire Apollo program many times over each year.

Here are a few examples where continued product development has benefited the customers with better, safer products:

Automobiles: The Model T progressed to the Lincoln Town Car.
Aircraft: The Ford Tri Motor progressed to the Boeing 777.
Computers: The Electronic Numerical Integrator and Computer (ENIAC) progressed to the Cray supercomputers in technological integration and their pervasive use in numerous mass market products.
Vacuum Tubes: The vacuum tube amplifier progressed through discrete transistors to integrated circuit amplifiers on a chip.

Incandescent Lights: The original incandescent light spawned fluorescent tubes and bulbs with numerous multiples of extended life. Fluorescent technology applied to bulbs using embedded electronics enable fluorescent light in a standard bulb socket.

The importance of continuing the product life cycle preserves the customer base. It drives competition between manufacturers in the marketplace. Competition is desirable and necessary. It prompts everyone to action to improve the products that they offer, so the customer and the manufacturer both benefit.

1. Differentiating Research and Development

A. Research expands core technology, development implements core technology

There is a unique and interesting relationship between research and development (R&D) in an organization. The two disciplines are diverse and separate, although they are often thrown together in conversation and lumped as one entity. In actuality, the two must function like a relay race, with research establishing the lead position and handing off the intellectual property and know-how to the development people to apply and create new products.

Research can be thought of as a strategic element of the organization, whereas development can be thought of as more operational in nature. Research is science-oriented. It translates phenomena into deterministic events, removes uncertainty, and is a resource tool for the development group. Often there is a disconnect between the week-to-week efforts of researchers and their respective development groups.

The operational issues with research include loose definitions of residual uncertainty; loose definitions of the delivered development tools; a loose definition of *deterministic*; and often a disconnect with the end-user of the technology, resulting in so-called projected customer acceptance.

Many problems in new product development occur when researchers have not completed their effort in totality. Time lines are not met, costs increase, and they forget that they are an integral part of the revenue-generating organization that must produce results on a specification and a time line to hit a window of opportunity.

Development, on the other hand, must focus on the creation of a product that can be manufactured and sold at a profit and achieve actual customer acceptance. Development engineers are charged with creating an accurate bill of materials, enforcing change management, creating documentation for manufacturing and product support, and testing. They also must identify and cement the product usage boundaries to ensure safety. Finally, they are charged with the human-factor engineering of a new product. Development has operational issues in establishing and maintaining linkages with research, ever more pressure on time lines, full absorption of uncertainty, funding constraints, compromises, and decision management between safety and cost. In total, they must translate customer needs into certified hardware.

For fast-moving technology companies, even research needs to be considered as operational, meaning it needs to have usable results, to be on time, to be well-defined, and to be easily transferable to development for industrialization and commercialization.

There are three basic types of R&D used in one form or another in industry today: incremental, radical, and fundamental.

Incremental research is best characterized by a small amount of research and some amount of development. This development is manifested by small, incremental improvements

in the product, manufacturing processes, and cost reductions. Not much research is required; however, continuous development is. These efforts generally have large, aggregated payoffs over time but can be unsung heroes of the corporation's profitability index.

The *radical type* is best characterized by a large amount of both research and development. This is the type of development that requires new knowledge to be discovered and understood, as well as development of the means to embody the know-how into a product for a specific purpose. Huge expenses in development follow huge expenses in research. The organization launching into this type of development requires immense amounts of capital to see the programs through to profitability.

The *fundamental type* of program is best characterized by a large amount of research and little or no development. Many times these programs degenerate into gathering knowledge for the sake of knowledge rather than gearing the research toward a specific goal. They may be strictly strategic in nature and won't have a payoff for many years. The senior management must have a great amount of faith and long-range vision because the rewards of the decision and subsequent sacrifice will accrue to the next generation of management.

B. Research expands core technology

Research and development have three major strategic goals in an organization. Their purpose is to contribute to the existing businesses by allowing the organization to defend market and product positions, support sales growth, and expand existing business.

Research fundamentally generates intellectual property for the organization. If the activities of the research element are directed properly, the intellectual property will have tangible value on a balance sheet. This asset will be eventually used to develop new products.

It is therefore incumbent on the senior management to carefully select the programs to fund. They need to select programs that are tied to operational objectives, have a time table and an end, and result in development generating revenue for the organization through product sales. Management needs to think through the vision of the future in today's time frame and assign research work that will generate timely results for the next product developments.

C. Development contributes and makes money through product sales

Development, on the other hand, takes the research, intellectual property, and know-how and generates products that can be sold at a profit sufficient to offset the other expenses of the organization. Figure 1-7 is a simplified illustration of the role of development.

It can best be characterized as a machine that has marketing input, operational input, and core technology available, and generates salable products that can be manufactured at a profit.

D. Development is much more measurable

The actual progress of development can be easily measured, since the development team is charged with the responsibility of committing to a schedule to produce results that are quantifiable. With the fundamental technology understood and made deterministic by the research function, development must concern itself with items such as bills of materials, performance, functionality, manufacturability, and cost. Milestones can be established and tracked with action items, responsibilities, and completion dates. Work content can be managed by manpower hours and loading in general, and results of expenses and time invested can be evaluated.

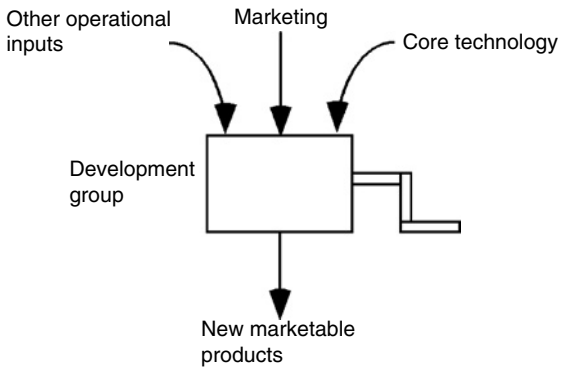

Figure 1-7. The role of development.

E. The need for research to be tied to operational goals

Because research generates the knowledge and is an integral part of development productizing the technology, it is very important for the research expenditure to be carefully made. Costs of progress from research to development increase dramatically, so diligence is required at the onset. Simply stated, ensure that research function is tied to operational goals. This means that the area of study must directly source the needs of development, and it, too, must occur on a time line. If not, development ends up cultivating the core technology and the project becomes irretrievably delayed.

F. The model for research and development

The following is a model for the research function and how it fits into the organization. Although organizationally the reporting relationship may vary, Figure 1-8 represents, in a general way, the flow of information and knowledge. It shows that information comes into research from several sources, including cooperative agreements with other companies' shared development in a consortium, from university sources, or from other sources

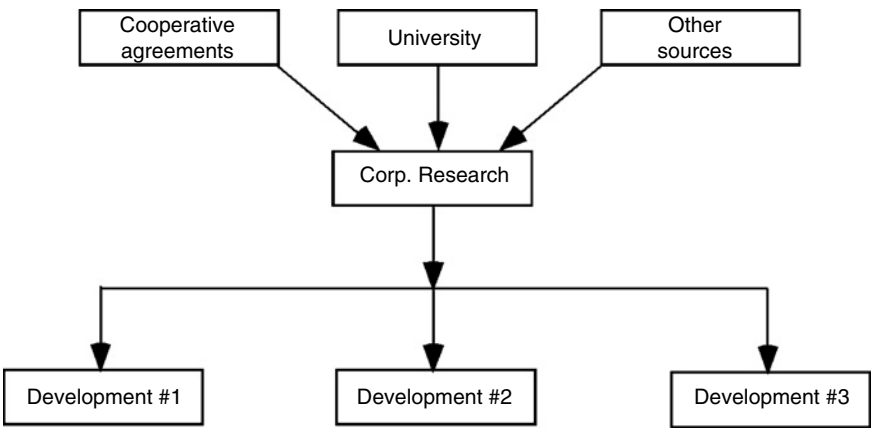

Figure 1-8. Core technology flow.

as required. The corporate research department then generates the core technology to lay into the development programs so products can be developed to hit a market opportunity.

On a strategic basis, Figure 1-9 illustrates how profits are derived from the efforts of research. The goals and objectives identified for the organization's future drive a strategy to achieve them. Research contributes to the development process, and profits are realized through operations. It is a critical link in the chain, and results are required in sequence and on time to be effective.

On a project basis, the research function must contribute knowledge at various points in the planning and development process. Figure 1-10 highlights this contribution of core technology. The project starts with a concept. The marketing analysis defines the customers' needs. Research then contributes the core technology—the necessary knowledge to determine project feasibility. It must answer the question: Can we as a company absorb and cultivate core technology and produce it cost-effectively to create a profit? At the point that the affirmative conclusion is reached, the core development of the technology begins. Research then transfers the technology to development. An integral part of the development is the industrialization of the product, and then commercialization. As shown in Figure 1-10, research contributes at two critical junctures in the process: at the feasibility stage to determine if the technology can be brought to product status, and at core development when research transfers the technology to development.

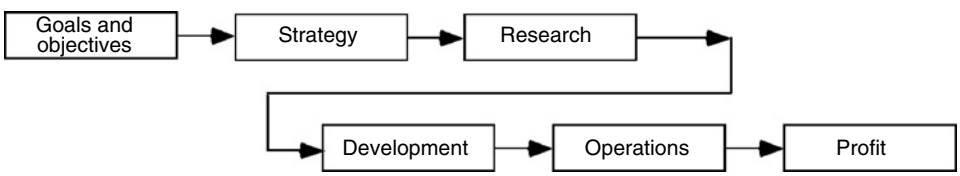

Figure 1-9. Research sequence to profits.

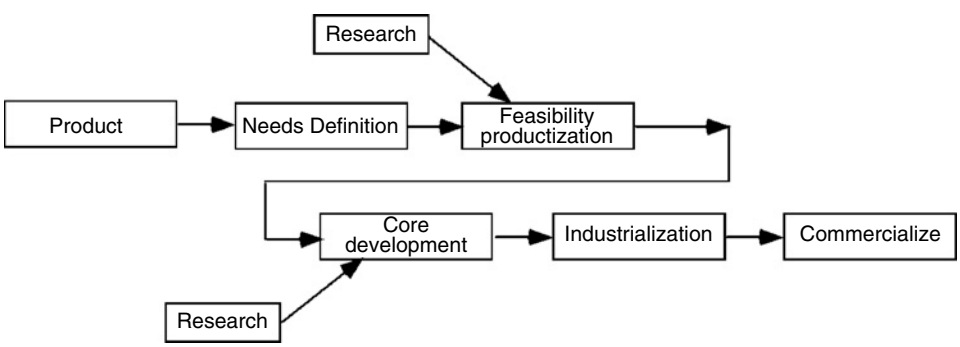

Figure 1-10. Research sequence to product.