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ESTABLISHING PERSPECTIVE

> During the last 100 years, we have created more wealth, reduced poverty more, and increased life expectancy more than in the previous 100,000 years. That happened because of entrepreneurs, thinkers, creators, and innovators. They are the heroes of our world.
>
> Johan Norberg[1]

How many people do you know who when asked "What would you like to be doing five years from now?" answer by saying that they would like to have their own business. In our experience, the percentage is very high. Perhaps this is because the desire to be free, independent, and in control of one's destiny is innate. However, realization of such a vision is not nearly as frequent as the desire. Key stumbling blocks are that people don't have the knowledge, resources, energy, or discipline to convert their dream into reality. This book is intended to help provide thoughts on how to bring good ideas to the marketplace. It focuses on and emphasizes technology. Technological innovations can be simple or complex, hardware or software, manufactured products or technology-based services, even systems

[1]Johan Norberg, "Entrepreneurs are the heroes of the world," *Cato's Letter*, Winter 2007, Vol. 5, No. 1.

Commercialization of Innovative Technologies: Bringing Good Ideas to the Marketplace, By C. Joseph Touhill, Gregory J. Touhill, and Thomas A. O'Riordan

that combine existing technology in a unique and imaginative way, but the pathway to successful commercialization is similar for all good ideas.

In addition to the huge audience of budding entrepreneurs who dream of starting their own businesses (including many who are actively involved in doing so now), there are many others who will find this book useful. Virtually all leading universities now have centers of entrepreneurship and teach courses on the subject to eager management and engineering students.[2] Today's investors are seeking ways to enhance their investment returns because the return earned from current stock, bond, and mutual fund investments is lower than it has been historically, and it appears that investing in real estate has taken on considerable risk. Hence, venture capitalists and consortia of investors[3] continue to look at the potential that innovative technology can have in realizing their target aspirations for significant returns on invested capital.

Another group of significant size that can benefit from this book are those who submit proposals to various federal agencies that award Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) contracts. SBIR is a program that encourages small businesses to explore their technological potential and provides an incentive to profit from its commercialization. STTR is a program that reserves a specific percentage of federal research and development funding for award to small businesses and associated nonprofit research institution partners. Because the risk and expense of conducting research and development can be beyond the means of many small businesses, STTR combines the strengths of small businesses and nonprofit research laboratories by introducing entrepreneurial skills to high-tech research efforts. Its intent is to transfer technologies and products from the laboratory to the commercial marketplace.

The U.S. Small Business Administration, Office of Technology's Web site (http://www.sba.gov/SBIR/) provides detailed information on how to become aware of proposal opportunities from agencies that award SBIR and STTR contracts. The Web site answers frequently asked questions and has a master schedule of release dates for solicitation announcements. Additionally, the Web site includes helpful links to agency/department SBIR and STTR program solicitations. Any small business interested in

[2]See Section 1.4 for a discussion of programs and curricula at leading universities that teach entrepreneurship and commercialization.

[3]These consortia, especially those that focus on smaller companies, commonly are referred to as *angel investors.* Interestingly, in 2004, angel investors financed nearly 45,000 startup companies to the tune of $24 billion. The majority of the startups were high-tech companies. These 225,000 active angel investors outspent venture capitalists, who funded $22 billion in high-growth startups. Angel investors are described in some detail in Chapter 4.

TABLE 1.1 Federal Agencies with SBIR/STTR Programs

Agency	SBIR	STTR
Department of Agriculture	×	
Department of Commerce	×	
Department of Defense	×	×
Department of Education	×	
Department of Energy	×	×
Department of Health and Human Services	×	×
Department of Transportation	×	
Environmental Protection Agency	×	
NASA	×	×
National Science Foundation	×	×

submitting proposals to federal agencies that fund SBIR/STTR programs is strongly encouraged to use this valuable resource for determining what agencies may be interested in their technological innovation, matching that interest with formal solicitations, and learning how to submit proposals.

There are 10 federal agencies that award such contracts (Table 1.1). Contract amounts are significant. For example, during fiscal year 2004, $2,015,000,000 was awarded for SBIR programs and $208,700,000 for STTR programs. One of the requirements of both SBIR and STTR is that proposers must demonstrate that their planned effort, if successful, will be commercialized. Thus, we envision that this book can serve as an inventor/innovator manual, a university textbook, an SBIR/STTR reference, or as a technology investment handbook. Additionally, business executives and management students will find it helpful in explaining the life cycle of product innovation and the dynamics of bringing good ideas into practice.

Unfortunately for all of these people, the old truism, "build a better mousetrap and they will beat a path to your door," doesn't always work. In fact, our experience shows that unless you know how to commercialize good technological ideas, people won't take your mousetrap even if you gave it away for nothing. The four key ingredients that make commercialization of good ideas successful are:

- Teamwork
- Planning
- Discipline
- Perseverance

We emphasize the first three ingredients explicitly throughout the book; the perseverance part is implicit, and truthfully, is learned best through experience. Of the key ingredients, we think that teamwork is the most crucial.

This is because we believe that the best chance for commercial success is through the formation of an *innovation team*. Surely there are occasional extraordinary people who alone can bring the germ of an idea to full commercialization, but these geniuses are few. In Section 1.2 we explain our rationale regarding teamwork in more detail and show how teamwork was an essential element in the birth of that great American phenomenon—Silicon Valley. Throughout the book we emphasize that an innovation team cannot succeed without a plan, and we spend time describing how strategy is formulated and how a plan is built. Finally, we stress that it requires discipline to follow a plan and wisdom to know when to amend it.

1.1 ORGANIZATION OF THE BOOK

We believe that enhancement of the human condition depends on thoughtful creation and implementation of innovative technologies. In these times of rapid technological expansion and global communications, most people recognize and understand the basic importance of intellectual property. Moreover, they understand the need for the entrepreneurial spirit to launch new enterprises. The winners will be those who know how to exploit good ideas and put them into practice. Our book defines a strategy for doing so and outlines an approach to commercializing innovative technologies successfully.

In the first three chapters we deal with *strategic* issues, answering such questions as:

- What is the audience for this book?
- Why is it so important to form an innovation team?
- Who are members of the innovation team, and what are some of their traits and characteristics?
- What does a strong and flexible commercialization plan look like?
- What are our objectives in developing a strategy for success, and how do we assess, develop, and manage promising technologies?
- How do we develop an endgame?
- What are key elements in executing the strategic plan?

In Chapters 4 through 16 we address *tactical* issues, such as how we find, fund, assess, develop, design, and demonstrate innovative technology. Whereas the first three chapters reflect boardroom decision making, the tactical chapters deal more with on-scene issues and problem solving. In Chapters 17 and 18 we focus on both strategic and tactical decision

making related to how a successful technology can be improved and what happens after our goal of successful commercialization has been achieved.

Some people claim that any worthwhile enterprise rests on a three-legged stool comprised of strategy, tactics, and operations. For our purposes in this book we have chosen not to address detailed operational matters explicitly. We leave this important area to others. Others have recognized the growing strong interest in entrepreneurship and commercialization of innovative technology, and some very good books on the subject have been published recently. Our book is different because we emphasize (1) the importance of the innovation team, (2) the wisdom of building a portfolio that spreads risk, and (3) the strong input required from technologists in the commercialization process.[4]

1.2 THE IMPORTANCE OF VIEWPOINT

It is extremely rare that a single person can conceive of an idea and then, alone, carry it through to successful implementation and commercialization. As technology increases in complexity and governmental rules and regulations become more pervasive and onerous, it is difficult to see how one person could bring a good idea to the marketplace without a lot of help. One of our main themes in this book is that successful commercialization is best achieved through teamwork. We believe that building an innovation team is crucial to the process of commercializing good ideas. Our conception of the innovation team that is best equipped to commercialize technology is one comprised of several personalities or roles, each with a different image of the idea or concept that we intend to implement[5]:

- Inventor/innovator
- Investor
- Technologist
- Entrepreneur

[4]Although the two junior authors have been or are associated with the U.S. Air Force, our primary audience is not defense contractors, but rather, people who are highly entrepreneurial and eager to make new ideas grow and go. The book subtitle, "Bringing Good Ideas to the Marketplace," reveals that we are focused on nascent ideas rather than mature technology that characterizes much of the defense community. Not that defense contractors won't find the book useful: To the contrary, many contractors would benefit from reading it, to find and promote new ideas. We see the typical reader as being young in spirit, eager, and bursting with energy and zeal. We hope to provide them with a road map and the benefit of a lot of experience.

[5]Accountants, lawyers, and bankers, among others, are important supporters of the innovation team, but are not regarded as core team members within the context of this book.

It takes all four of these personalities to identify and evaluate good ideas and concepts and then bring them to the marketplace profitably. The best pathway toward successful commercialization requires that the innovation team be flexible and interact well, focusing on the common goal of profitable commercialization. Sometimes people will switch roles as an idea is evaluated, matures, and is developed. Thus, each role, whether undertaken individually or in combination, is vital to successful commercialization.

The Birth of Silicon Valley: The Traitorous Eight

During 1996, Public Broadcasting aired a television show called, *Caesar's Writers*. It was riotously funny, but more impressive was the story of how a group of very talented writers made it possible for an outstanding comedy ensemble headed by Sid Caesar to capture the relatively new medium of television by storm. *Your Show of Shows*, produced in the early 1950s, remains for many people the gold standard of television comedy. Where Milton Berle's slapstick captured the nation's funny bone, Sid Caesar and his cast taught us the meaning of wit. The truly amazing part of the 1996 reunion of Sid Caesar and his writers was the identity of the writers[6]: Mel Brooks; Larry Gelbart; Gary Belkin; Sheldon Keller; Carl Reiner; Aaron Rubin; the Simon brothers, Danny and Neil; Mel Tolkin; and a very young freelance contributor of jokes—Woody Allen. The show itself was terrific, but to recognize the incredible talent of the comedy writers and what they accomplished collectively over the years was astounding. Just suppose that there is a parallel story in high technology. Well, there is!

In December 1947, two scientists, John Bardeen and Walter Brattain, at Bell Telephone Laboratories in Murray Hill, New Jersey, observed that when electrical signals were applied to contacts on germanium crystals, the output power was greater than the input. Their boss was the magisterial William Shockley. Shockley sought to find an explanation for the phenomenon, and with great insight over a short period, he not only explained the effect on semiconductor materials, but also, and more important, developed a crystal that became known as a junction transistor. By 1951, Shockley and his crew had reduced the transistor to practice. In 1956, Bardeen, Brattain, and Shockley shared a Nobel Prize in Physics for their discovery.

[6]The great Lucille Kallen was not in the program, although she was an essential part of the writing team.

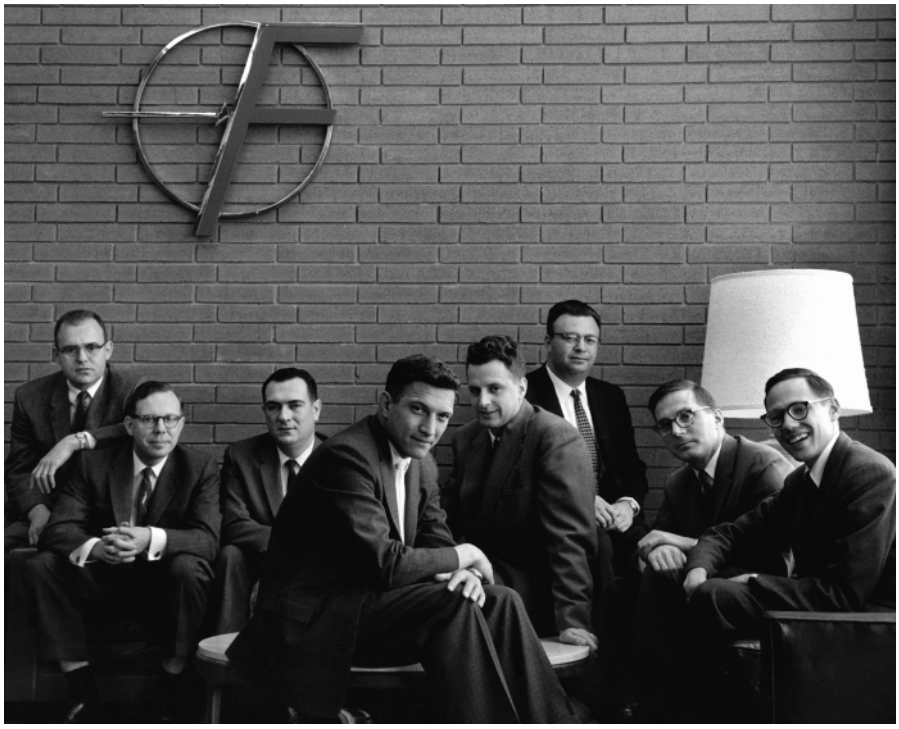

FIGURE 1.1 The Traitorous Eight at Fairchild Semiconductor in 1959. From left: Gordon Moore, Sheldon Roberts, Eugene Kleiner, Robert Noyce, Victor Grinich, Julius Blank, Jean Hoerni, and Jay Last. (Courtesy of Wayne Miller/Magnum Photos.)

Shockley believed that Bell Labs wasn't moving quickly enough to capitalize on his work, so in February 1956, with financing from Arnold Beckman of Beckman Instruments, Inc., he founded Shockley Semiconductor Laboratory in the San Francisco Peninsula, near Palo Alto. He hired a group of talented young scientists to develop the new technology. During the course of their work, they noted that silicon had many advantages over germanium. Shockley, not a man to act kindly toward criticism even if it was only his perception, reluctantly permitted the young scientists to explore this apparently better route. However, his management style became increasingly difficult for his researchers.

In the words of Gordon Moore, one of these young researchers and eventual cofounder of Intel[7]:

[7]Gordon Moore, "William Shockley," *The TIME 100, Scientists and Thinkers*, Mar. 29, 1999.

> Working for Shockley proved to be a particular challenge. He extended his competitive nature even to his working relationships with the young physicists he supervised. Beyond that, he developed traits that we came to view as paranoid. He suspected that members of his staff were purposely trying to undermine the project and prohibited them from access to some of the work. He viewed several trivial events as malicious and assigned blame. He felt it necessary to check new results with his previous colleagues at Bell Labs, and he generally made it difficult for us to work together.

Unfortunately, things went from bad to worse. So in May 1957, eight employees—Julius Blank, Victor Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore, Robert Noyce, and Sheldon Roberts—went to Arnold Beckman and said that they could no longer work under Shockley's oppressive management. They suggested that they needed a new manager, but said they would not have a problem if Shockley remained as a consultant. Initially, Beckman agreed, but two months later he changed his mind.

That was it. In September 1957, the eight men resigned. Together they were able to scrape up only $3500 between them. They needed help, so Eugene Kleiner wrote a letter to his father's stockbroker in New York. Somehow the letter wound up in the hands of a legendary venture capitalist, Arthur Rock. Rock went to California, liked what he saw, and persuaded Sherman Fairchild, the inventor of the aerial camera, to make the eight young researchers a subsidiary of his company. With a contract for $1.3 million, they became Fairchild Semiconductor and built transistors their way. Shockley was outraged and referred to these men as the Traitorous Eight. He never recovered from losing these talented scientists, and in 1963 he left the electronics industry and went to Stanford University.

What the Traitorous Eight would do next would change history. Committed to development of the silicon-based semiconductor, the eight men set up shop in an area renowned for its apricot groves. They quickly made their semiconductor technology the de facto standard for electric switching devices and produced components that would dominate a wide variety of industries, from consumer electronics to the nascent space program. Within two years, the new Fairchild Semiconductor subsidiary was creating more revenue than that of its parent company.

The eight made Fairchild Semiconductor a huge success, but like Sid Caesar's writers, what the Traitorous Eight became is the best part of the story. They essentially invented Silicon Valley. Victor Grinich became a professor at the University of California at Berkeley and Stanford University; the other seven went on to found notable spin-off companies.[8] Robert

[8]The spin-offs and their founders often are called "Fairchildren."

Noyce and Gordon Moore became cofounders of Intel. Eugene Kleiner cofounded the world-renown venture capital firm Kleiner, Perkins, Caufield and Byers. Sheldon Roberts, Jean Hoerni, and Jay Last founded a company that later became Teledyne, and Julius Blank cofounded Xicor.

Their impact on high technology was immense. In the words of Jay Last: "The first 50 years of transistors were very similar to the first 50 years of the Gutenberg press. They happened 500 years apart, and they trace almost the exact same path. Both became mature industries within the same amount of time. The [integrated circuit] changed the world the way the Gutenberg did—but even more so—by giving us this enormous ability to communicate."

The common thread in this story is the value of *teamwork*. It takes a brave person to challenge a Nobel prize winner at his own game, but like the Three Musketeers, the Traitorous Eight truly were "One for all and all for one." Convinced of the value of their technology and their vision of what it could produce, the Traitorous Eight bravely gambled their professional reputations and futures together. Once they had made the break from Shockley, together they began the development of one of the greatest technical transformations in the history of humankind.

Especially notable for the Traitorous Eight is who these young technologists morphed into. Some became seasoned technologists, some venture capitalists, some entrepreneurs (and very good managers to boot), and some even bounced between roles. Clearly, they understood teamwork and exemplify what an innovation team should strive for. These men created an environment that permits high technology to flourish today, and they will remain models to emulate for a long time. The Traitorous Eight were a bold and committed innovation team that changed history.

To build a successful team, the mind-set of each person or role must be understood. Hence, we begin here with descriptions of the traits of the various players in their distinctive roles. For each role we include a brief profile of a person or persons who represents (at least to us) the essential characteristics that we associate with various facets of the innovation team. Note that several of the persons cited assumed multiple roles throughout their careers.

1.2.1 The Inventor/Innovator

Inventors/innovators are a different breed. They see things in ways that most people don't. That's why they are so good at what they do. Even

though their ideas or concepts may be technologically based, they don't necessarily have to be scientists. They are usually more interested in practice than in theory. Not that they don't understand the theory—but it's the application that consumes them. A classical example of the consummate inventor is Thomas Edison. Clearly, he was extremely pragmatic in the way he approached his experimentation, but to believe that this brilliant man didn't understand and have command of the scientific principles that were the foundation of his successes would be a grave mistake. Let's look at some of the words that come to mind quickly when we're describing inventors/innovators.

Creative The characteristic that most people associate with inventors/innovators is creativity. Ideas and concepts that they come up with seem remarkable to us. "Holy cow! How come I didn't think of that?" The reason is that they see things differently within the context of their experience and education. Moreover, and perhaps most important, they can visualize the application and usefulness of what they conceive.

For purposes of this book, we distinguish inventors/innovators from tinkerers, although sometimes it's hard to tell the difference. For example, Floyd Paxton of Selah, Washington became fabulously wealthy by inventing and patenting the plastic clip that is used on bread bags. Although his biography refers to him as an inventor, clearly nothing else he did commercially rivals the success he had with the bread clip. Perhaps he would not qualify for the tinkerer sobriquet either. Nevertheless, our focus here is on the technically oriented person who works in a disciplined way to conceive and develop products and procedures for the technology marketplace. According to one dictionary, a tinkerer is a person who "manipulates unskillfully or experimentally." In our experience, tinkerers today, except in rare cases, simply can't keep up because of the rapid pace of technology expansion. Although Edison hardly was a tinkerer, today his trial-and-error methodologies would be too expensive and time-consuming without consideration and thorough understanding of scientific fundamentals and the shortcuts that they enable.

Inventors/innovators often have lots of good ideas that deal with potential applications in highly varied fields. A good example is Dr. Edward Teller, famed physicist and so-called Father of the H-Bomb, who collaborated with chemists Brunauer and Emmett to develop the famous BET equation, which is the most commonly used method of measuring the surface area of multilayered adsorbent materials. A great strength of Teller was that he had the ability to simplify complex problems, a common characteristic of inventors/innovators. That is a key reason why they are good at generating useful concepts.

The broad interests of inventors/innovators can hamper their creativity. They are diverted easily because of their quick minds and diverse ideas. This often interferes with their focus. Lack of focus is sometimes paradoxical in view of their stubborn single-mindedness most of the time. They also have been accused of being poorly disciplined, due to their occasional inattentiveness. This accounts for the mostly unfair description of "mad scientist."

Passionate Innovation team members must be acutely aware of the inventor/innovator characteristic of being passionate about their ideas and concepts. It colors their behavior dramatically. When they come up with what they see as a great idea, they believe absolutely that it is the greatest boon to humankind. It's like one of their gifted children. Try to remember that lots of sweat and tears went into the conception of the idea. In fact, many ideas represent generations of failure before the concept is honed into what the inventor believes will prove to be a huge success. So when other innovation team members grill the inventor, we urge that they do so with gentleness and respect just as if they were inquiring into the prospects of the inventor's favorite child.

We are reminded of one inventor we knew who became blinded by his zealotlike commitment to an invention that he had developed over a period of nearly 20 years. He would accept no criticism, even if it was positive. His passion became blindness. Eventually, on the brink of losing everything that he owned, he capitulated and grudgingly permitted an investment group to take ownership of the idea. Fortunately for him, they were decent people who not only paid him a fair price for his asset, but also retained him for many years as a well-paid consultant. Unfortunately, many ultrapassionate inventors are not so lucky and drive investors away. Eventually, their ideas flounder and disappear.

Protective When inventors/innovators have to seek funding for their ideas, they make it hard to deal with them. All of them believe that if they were independently wealthy, they would fund the entire venture on their own. But they usually run out of their own money[9] and understand that to achieve full commercialization potential they need resources well beyond what they can provide themselves. But here's the problem: They are highly reluctant to share the basis for the inner workings of their idea. In addition, they tend to be suspicious and believe that if they aren't

[9]This doesn't necessarily mean that they exhaust all of their financial resources, but it does mean that they have reached the limit that they have established for what they are willing to risk. The risk/reward concept is a key in negotiating with them in sharing ownership and equity.

careful, somebody is going to steal their idea. As a result, they don't want to reveal anything. They want investors to trust them and simply write checks. Clearly, that's not the way things happen.

To inventor/innovators, any darned fool can see what a great idea they have. But those who are going to spend money and time developing the idea and concept have to know how it works and why it works, sometimes in excruciating detail. And what's obvious to the inventor probably isn't all that apparent to the other innovation team members. So inventors/innovators have several courses of action: They can simply surrender their reluctance and trust the other team members; they can use detailed confidentiality agreements and apply for patents; they can structure development agreements that include confidentiality provisions and rights of control of technological intellectual property; they can enter into elaborate consulting contracts; they can move on and try somebody else; or they can try a combination of the above.

In early stages of development, patents aren't the complete answer. Some people believe that patent applications are sufficient protection for nascent ideas. A patent application helps, but what really protects young ideas is the proprietary knowledge of the inventor. Moreover, if the idea is a blockbuster, patents are a road map for those who would reverse-engineer and/or copy and modify the concept.

At the outset, innovation team members often don't know each other that well, so the trust necessary to make the team function efficiently hasn't developed yet. All the legal agreements in the world can't engender that trust. So if all parties believe in the idea and they want to move ahead but are stymied by the inventor's recalcitrance in revealing details, there is another alternative that we have used successfully. It is the concept of a technological trustee, and it works like this. Both parties—for example, inventor and investor—agree that a third party will be the repository for details of the idea or concept. The inventor will reveal all the details of how and why the idea works to the third party, the technological trustee, who is judged to be an expert in the area of application. The trustee, through a thorough probing, will form an overall opinion of the idea and will share this opinion with the investor. Thus, the inventor trusts the trustee to retain the idea and all the details in secret, and the investor trusts the technological opinion of the trustee sufficiently to lend money for development of the idea. For one client we were part of such an arrangement for 13 years. During that period, the concept was developed and implemented. When all parties believed that their interests were protected, they terminated the agreement and released us from our trustee responsibilities. The fact is: All of the innovation team members finally trusted each other.

Because protection of the concept and details of the innovation are so important to the inventor, they should have a strategy worked out in advance of any contact with investor groups. By doing so, everybody will save a lot of time and friendlier negotiations will be promoted.

Persevering With regard to their favorite ideas, inventors/innovators are like elephants and bulldogs: They never forget, nor do they ever give up. These characteristics have both a positive and a negative side. Endurance causes them to persevere in the face of derision, experimental failures, and monetary problems. They will wait potentially forever for true appreciation of their ideas. Conversely, it makes them stick too long with "turkeys". With them, bad ideas hang around much longer than they would with other innovation team members.

Somehow, inventors have to learn to step back and analyze as objectively as possible where they stand in their quest for commercialization. Moreover, they should try to understand the motivations of other team members. Doing so will help speed the commercialization process measurably. Dedication, perseverance, and endurance are admirable, and they make inventors/innovators tough and thick-skinned. They may also make it difficult to get along and deal with them.

Stubborn Stubbornness in inventors is a characteristic closely aligned with both passion and perseverance. We already have talked about an inventor's unwillingness to divulge trade secrets, and there are related traits. After reaching an agreement with others to set up an innovation team, it is not uncommon for inventors to be less than eager to make changes in their original concept, even if such a change represents a clear improvement. They are often not very receptive to the ideas of others, especially those who they believe don't have the technical background to understand how and why their concept works. In fact, some very talented inventors who we have encountered think everybody else is stupid. Fortunately, most (but not all) keep that thought to themselves.

It is interesting that despite their foibles, most of the inventors we have worked with are very good negotiators. They may not be particularly good businesspeople, but they are very effective in negotiations because they are willing to walk away if they aren't comfortable with the terms of the discussions. Most inventors have labored long and hard to get to the table, and the last thing they will tolerate is relinquishing more control than they believe is fair. They are the final arbiters of what's fair, so the best way to approach them in any matter that requires negotiation is to appeal to them rationally and intellectually.

Those Who Failed in Their Success: Philo T. Farnsworth and Allen B. DuMont

Are you ready to appear on *Jeopardy* and identify the inventor of television? The ubiquitous staple of every home today was the product of the fertile minds of Philo Taylor Farnsworth, who invented television technology, and Allen B. DuMont, who invented the capability to mass-produce cathode ray tubes and created the DuMont Television Network to broadcast programs around the country. Both of these men epitomize the attributes we showcase as the hallmarks of inventors.

Farnsworth and DuMont were exceptionally creative from their early childhoods. Farnsworth, born in a log cabin in rural Utah, developed the technical concept of television as a 14-year-old. While plowing fields, he came upon the idea that like the plowed lines of his field, he could create images on etched glass with a focused electron beam. He sketched his design for his high school teacher, and after a year at Brigham Young

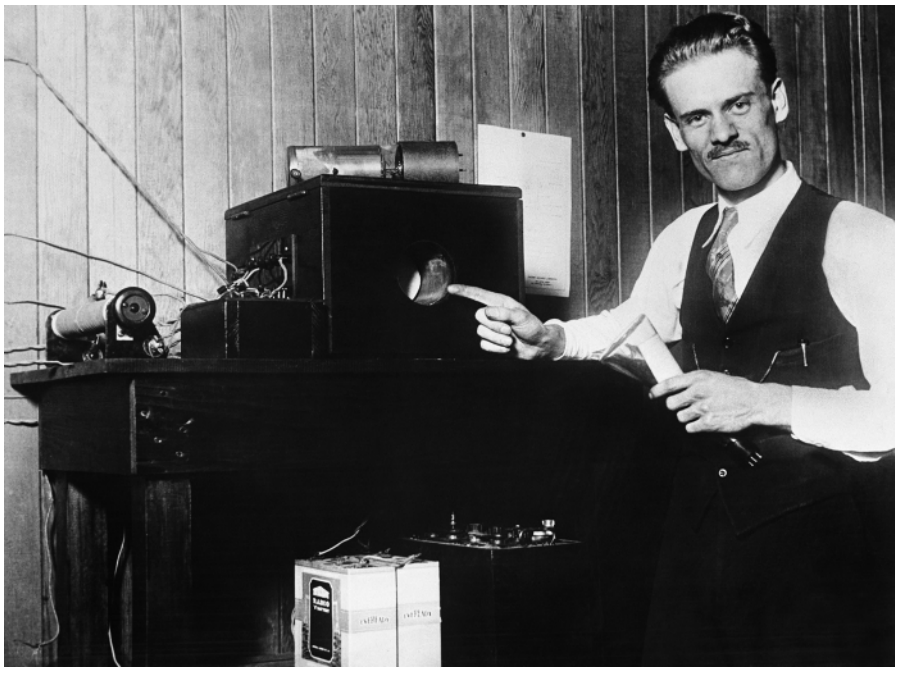

FIGURE 1.2 Philo T. Farnsworth points to his television. (Copyright © Bettmann/Corbis.)

FIGURE 1.3 Allen B. Dumont. (Courtesy of Institute Archives and Special Collections, Rensselaer Polytechnic Institute, Troy, New York.)

University he created a laboratory in which he soon created the first all-electronic television image. Similarly, DuMont, who was afflicted by polio as a youth, demonstrated his genius early in life by mastering electronics. During his recuperation from polio, he built—and repeatedly rebuilt—radios, incorporating significant improvements in each version. By the time he was 14, he had become the youngest American to obtain a first-class commercial radio operator's license.

Passionate about their work, both men were dogged in their determination to pursue their inventions. Settling in San Francisco after his one year of college, Farnsworth aggressively sought investors and when he was 21 years old set up a laboratory where he created a working television camera (the "Image Dissector") and transmitted the first television image. DuMont rapidly built a reputation as a genius following graduation from Rensselaer Polytechnic Institute. Hired by Westinghouse fresh from college, he quickly transformed their tube production capability from 500 tubes per day to over 50,000 tubes per day. DeForest

Radio enticed him to leave Westinghouse, but soon he felt stifled and left to create his own company, DuMont Laboratories, which became the world's leading manufacturer of high-quality cathode ray tubes. He had just turned 30.

Farnsworth and DuMont were very protective of their inventions, and one might speculate that this was a principal reason that each created his own laboratory to develop and manage their products while retaining complete creative and production control. People typically think of inventors as having struggled for years to perfect their creations; they exemplify endurance. In this regard, Farnsworth and DuMont are not exceptions. For Farnsworth, from concept to creation, the development of a working television system took seven years. DuMont, who toiled in the basement of his New Jersey home to create a long-lasting and reliable cathode ray tube, poured his heart and soul into a company that he would run for nearly 30 years.

Their endurance was matched by their stubbornness. For many years, Farnsworth was engaged in a prolonged and particularly nasty legal struggle with the Radio Corporation of America (RCA) and its president, David Sarnoff. Vladimir Zworykin, who was affiliated with RCA, had received a patent for a device he called an "iconoscope." Ironically, the iconoscope was remarkably like Farnsworth's Image Dissector. In promoting his expanding radio empire and planned television network, Sarnoff scoffed at the thought of acknowledging Farnsworth's invention, let alone compensating him. "RCA doesn't pay royalties," he is alleged to have said, "we collect them." Although the U.S. Patent Office ultimately sided with Farnsworth, it took years of litigation before he received a dime from RCA, and he died penniless and in obscurity.

DuMont also demonstrated brilliance punctuated by stubbornness. DuMont parlayed his success in creating and selling the world's best cathode ray tubes into creation of the DuMont Television Network, the first television network in the world. Facing fierce competition from rivals NBC, CBS, and ABC, DuMont was plagued by lack of a strong affiliate structure. Despite having a few now-famous shows, such as *The Cavalcade of Stars* (featuring Jackie Gleason), Bishop Fulton Sheen's *Life Is Worth Living*, and *Captain Video* (the principal author's favorite), DuMont could not capitalize on his early success and develop the fledging network and make it profitable. Soon he was sinking significant amounts of money from other parts of his company into the television network to keep it afloat. Colleagues and board members alike insisted that in the wake of mounting losses, he terminate or sell the network. DuMont would have none of it and in 1956 was compelled by his corporate board to sell the failing network to Metromedia. Ironically, Metromedia was later acquired

by Fox Broadcasting, and many Americans now routinely turn on their local Fox affiliate to watch their favorite baseball or football games. Perhaps DuMont, who died in 1965 with his companies in the hands of others, would be satisfied in knowing that he was right—just ahead of his time.[10]

Human history is rife with stories of inventors such as Farnsworth and DuMont. The common threads are the attributes we find common to all inventors: creativity, passion, jealous protectiveness of their ideas, the perseverance to see their ideas through, and stubbornness in the face of naysayers. Yet, as was true for the inventors we profiled, these attributes are sometimes blessings but may become curses when not managed properly.

1.2.2 The Investor

Investors are persons or groups who furnish money to bring a good idea or concept to a conclusion, either good or bad. Usually, investors enter the picture after the inventor/innovator runs out of funds or time. Remember, inventors/innovators would usually choose to do it all themselves if they had unlimited resources. Investors are allowed in when inventors see the opportunity evaporating; when their patience and enthusiasm are flagging and they are looking to get on with the next bonanza; when they are starting to see weaknesses in their idea; or when they really begin to understand that they need financial and technical help. The contrast between inventors and investors is fascinating. Inventors are creative and emotional, whereas investors are cold and calculating.[11] Yet each of these two parts of the innovation team is absolutely essential to the other.

The first rule in technology investing is to avoid using family and friends as sources of money. Even if such persons are wealthy enough to accept failure, and even if they are eager to help even when we don't ask, it is best not use them if at all possible. Some of the biggest feuds have occurred not when there was failure but when the commercialization went very well and it came time to make critical decisions and to divide up the profits. In addition, and perhaps more important, relatives and friends probably love us a lot more than they love our ideas, inventions, and innovations. Chances are they don't really understand what we are

[10]We talk about the importance of timing throughout the book.

[11]Clearly, this is a wild generalization and reflects tendencies rather than absolute categorization.

attempting. Yet somehow they believe that their monetary involvement will give them special privileges in the management of the company, something at which they are probably woefully inept.

Rather than relatives and friends, we urge the use of professional investors who build suites of technology. They understand the science, the process, and the risk better, and they can be far more helpful in making the commercialization work because they are experienced in business and will be much more objective than parents, siblings, and childhood buddies. The enormous success of Silicon Valley investment groups provides abundant proof that working with professional investors enhances substantially opportunities for commercial success. Just as with inventors/innovators, investors have their own set of characteristics that distinguish them as members of the innovation team.

Good Sense of People Arthur Rock, who coined the term *venture capitalist* (see "The Man Who Turned Apricot Orchards into Silicon Valley" below), says that the key attribute of an investor is the ability to identify successful people and invest in them. "What I'm interested in is investing in people. And I look for people who, you know, everything you could think of. They're honest. They have fire in their belly. They're intellectually honest, meaning that they see things as they are, not the way they want them to be and, and have priorities and know where they're going and know how they're going to get there."[12] Because successful innovation teams begin with visionary people, the investor is always on the lookout for those with the "right stuff."

Well-Connected Another important attribute of the successful investor is being well-connected with those who present opportunities for success. Many of us look at the recent successes of companies such as Microsoft and Apple and wonder what our lives would be like if we had the opportunity to invest in them early in their development (imagine the return on investment!). Our research has shown that the investor who remains engaged in and connected to the marketplace soon finds that many inventors with good ideas come to them in search of investment. The acme of skill of a discerning investor is to determine which idea is a blockbuster and which is a dud.

Focused on Monetary Return Many inventors/innovators envision investors as being like the main character in George Eliot's novel *Silas Marner*,

[12]http://silicongenesis.stanford.edu/transcripts/rock.htm The quote is in fractured English because it was extracted from an interview, but we believe that the reader can easily see the intent of Rock's response.

who spent a great deal of his time counting gold coins. What they forget is that Silas Marner turned out to be the hero of the novel.[13] Despite the fact that investors don't always have a clear understanding of the technological concept, they do understand money. They understand money as a measure of performance. This perspective is not necessarily bad. In fact, this focus helps to improve fuzzy ideas and prompts creative and beneficial variations and improvements. Members of the innovation team, especially inventors, should listen closely to the probing questions of investors and address their doubts and fears. The reason is simple: To win the game you need a rational and objective scorecard.

Just as it is crucial for investors to focus on return on investment and profitability, they must also keep a tight rein on the spending of money during the entire commercialization and development process. The most important question they can ask when requested to write a check is: "Why?" This helps the entire innovation team to remain grounded in the reason for which they chose to participate to begin with. It also helps everybody to remain committed to the original goals. Be advised, however, that we have found that the most successful investors are not focused completely on monetary return. They are very mindful of monetary return, but their primary focus is to keep the innovation team concentrating on the thing that keeps the team solvent—the most crucial resource of all: human capital.

Impatient Investors have a reputation for being very impatient with the rest of the innovation team because of the time it takes to evaluate, assess, plan, develop, build, test, sell, fix, and monitor the new idea. There are a couple of reasons for this. First, they usually don't fully understand the technical aspects of the idea, so they don't appreciate the complexities involved in moving toward commercialization. Second, they don't realize the amount of sweat, tears, and emotional, financial, and intellectual sacrifice that went into the early conception and development. Third, from their perspective, time is money, and the longer it takes to reach the goal, the lower the return on their investment. The net result is that they want results as soon as "impracticable." It is essential that this impatience be addressed.

It is important that all members of the innovation team agree at an early stage on a reasonable timetable for accomplishing the various phases of the commercialization cycle. To arrive at such a formal timetable, judgment,

[13]Soames Forsyte, the central character in John Galsworthy's *Forsyte Saga* novels, is another investor who ultimately is redeemed despite his consuming focus on "property."

tact, and flexibility[14] are needed when bargaining. One reason is because inventors/innovators especially, and technologists invariably, are overly optimistic in making up schedules and budgets. It is their nature. In fact, the team probably doesn't want to deal with inventors and technologists who are very conservative on these two issues because it's an indicator that either they don't believe in the concept or don't know what they are doing. Once agreed upon, the formal timetable focuses on the tasks at hand and establishes accountability.

In their eagerness to get a quick return on investment, investors sometimes unrealistically push too hard for results.[15] If that becomes a source of acrimony, the team should quickly identify the disconnect and disband the association before the concept becomes bound up in protracted legal battles. Many excellent ideas have been killed due to squabbles that slowed progress to a crawl and lost their time-sensitive window of opportunity.

Capitalistic Many inventors/innovators are driven, in part, by altruism. They are eager to impart to the world what we referred to earlier as "the greatest boon to humankind." They extend this hyperbole to their characterization of capitalistic investors by suggesting that investors could not care less. The innovation team must help inventors/innovators realize that the goals of their altruism can only be achieved by making the commercialization process work. Hence, they have to come to a reasonable compromise in understanding that free-market capitalism does not exploit people but is really one of the best mechanisms for improving the condition of humankind.

Dispassionate Investors are most often regarded as being dispassionate about the idea or concept to be developed and really interested only in the money.[16] This isn't necessarily a bad thing. The best characteristics of investor dispassion are objectivity and realism. The innovation team should not subordinate this trait in investors. In fact, they would do well to showcase it.

Dispassion must not be confused with detachment. Detachment can lead to a lack of interest, which in turn can result in a lack of focus, deficient

[14]Flexibility is especially important in all phases of the commercialization process and is discussed at length in Section 1.3.

[15]Remember the old story that venture capitalists believe that if a woman can have a baby in nine months, nine women can have a baby in one month.

[16]Once again, the characterization of investors as being money-grubbing troglodytes grossly oversimplifies the situation and usually isn't true. On the other hand, investors are slow to disabuse other team members of this opinion so as to retain close reign over spending.

discipline, and sloppiness. These are deadly sins not just for investors but for the entire innovation team. Conversely, investors must guard against becoming too attached to an idea. Too often, investors become immersed in the thrill of technical developments and lose the objectivity that is necessary to keep the process on track.

Not Interested in Technical Details Investors often are accused of not being interested in technical details. Lack of interest must be contrasted with failure to understand the technology of a concept. The role of investors should be to understand the big picture of the potential impact of successful development and commercialization. It's not necessary that they be able to derive equations or reproduce experiments, but they should strive to have a good appreciation of what the inventors and technologists are attempting to do and the implications of successful accomplishment. In actual fact, some of the best investors were at one time inventors or technologists. As they became more successful, they envisioned themselves moving up the food chain to the role of investors.

In the course of becoming knowledgeable, investors must guard against micromanagement. Remember that all the roles of the innovation team demand people with strong personalities and convictions, and such people usually regard micromanagers with distain.

Finding Investors There are many investors who are eager to find good ideas. For example, it is estimated that there are nearly a quarter of a million active angel investors alone, not counting professional venture capital organizations. The trick is how to find the right one to form an innovation team. One way is to go to the Internet and type "venture capitalists" and "angel investors." The problem is that we will probably collect too much information and have too many choices. To refine the broad Internet approach, we suggest that readers try www.en.wikipedia.org as a sort of primer on the subject, then go to the Internet and be more selective. It is usually good advice to seek angel investors and venture capitalists in the region in which the innovators/inventors live and work.

A better approach is to learn as much as possible about the business field that a potential investor wants to enter. Attendance at technology conferences run by professional societies is one good way to create a network of contacts. If we know who the big guns are in our area of interest and do our homework, the list of potential investors will become manageable in a hurry. In addition, we establish our own network of people who can help to identify prospective investors.

The Man Who Turned Apricot Orchards into Silicon Valley: Venture Capitalist Arthur Rock

In 1957, a group of eight scientists, disenchanted with the management style of their Nobel prize–winning boss, William Shockley, walked out of Shockley Semiconductor Laboratories in Palo Alto. Armed with the technical expertise to commercialize the semiconductor, the foresight to know that their product could change the world, and the drive to make it happen, they merely needed the money to get a new company started. The Traitorous Eight, as they became known, enlisted the help of a visionary investment banker from New York, Arthur Rock.[17]

After his first visit to northern California, Rock became a believer in the group's vision and set out to sell their idea to potential investors. Thirty-five companies turned him down; investing in something at the idea stage was too foreign to them. Eventually, Rock found Sherman Fairchild, an inventor willing to risk some of his family fortune on the venture. With a simple handshake between the two, northern California was changed forever—Fairchild Semiconductor, the first transistor company to work solely in silicon, was born. Later, several spin-offs would emerge, including, with Rock's backing, Intel, now the world's largest producer of microprocessors. Equally important, the idea of stock options for employees and the use of venture capital financing became a standard part of the nascent high-technology industry.

Arthur Rock serves as an excellent example of the ideal investor: having an incisive sense of people, being well-connected in business markets, possessing a sharp eye for the best return on investment, having the ability to take a dispassionate view of the technology and its potential, and lacking interest in the minute technical details. As one of the founding fathers of venture capital, and the man credited with coining the term, Rock was a major player in the development of Silicon Valley. Working with Thomas J. Davis, Jr., in the firm Davis & Rock, as well as on his own (as Arthur Rock & Co.), Rock backed many of the companies that make Silicon Valley what it is today: Teledyne, Scientific Data Systems, Apple Computer, General Transistor, and Diasonics, to name a few.[18]

Rock once described the role of a venture capitalist as someone who hunts for entrepreneurial dreamers possessed of "the potential to change the world." Rock analyzed the potential of a young company by focusing on the entrepreneur. "People, people, people," said Rock, in describing

[17] http://www.alumni.hbs.edu/bulletin/1997/december/rock.html.
[18] Ibid.

how he chose companies to invest in.[19] Once Rock invested in a company, he remained active in its management. He is a director of Intel and Apple, for example, and vice chairman of Diasonics. He stays in close touch with his managers, most of whom recognize that his advice is worth far more than his money. He maintains a delicate balance between guiding them and letting them find their own way.[20]

Rock's professional manner is detached and clinical. He refuses to let his companies waste money and conveys a harsh sense of urgency. He says little at board meetings, and sometimes will squelch woolly ideas by asking abruptly, "What good will it do?" Says his one-time partner, Thomas Davis, a California venture capitalist: "He only wants the right answer." Behind Rock's understated exterior lurks a remorseless will. Notes California financier Max Palevsky: "Arthur makes it clear you had better win and you had better work your ass off all the time."[21]

"Innovation and new ventures fuel the global economy but the spark comes from investment," Arthur Rock said. "Investment is about trust. It's about knowing that the people investors entrust with their money are running ethical, transparent and effective businesses."[22]

1.2.3 The Technologist

As you will discover during the course of this book, we relate most with the role of the technologist. This bias is understandable because that's where most of our commercialization experience is based. Other team member personalities tend to be flashier and at times more volatile, but be assured that technologists have their moments, too. We see the technologist as a strong force that makes an idea work and makes the prototype into something that's practical and affordable. Without that practicality and cost-consciousness, the product is going nowhere. To be viewed as a cohesive team member who works for on-time performance, cost-efficiency, and a useful product that will sell well, a technologist should actually cultivate the trait of quiet rationality.[23]

Sadly, the role of technologist is frequently omitted from the commercialization process, despite its critical importance. This omission can lead

[19] http://www.bookrags.com/biography/arthur-rock/.
[20] http://www.time.com/time/magazine/article/0,9171,949965-2,00.html.
[21] Ibid.
[22] http://www.law.stanford.edu/news/pr/3/.
[23] Or at least should convey an appearance of "quiet rationality."

to incomplete development of the idea, faulty products, or outright failure. The reason given most often for not having a technologist on the innovation team is that it costs too much money. Our retort is to ask "Why would you skimp on the phase of the commercialization process that is most important to success?" The answer of really accomplished innovation teams is: "We don't skimp on any aspect of the process, especially technology!"

Focused on Technology The primary role of the technologist is to test the inventor's technology to see if it really is a good idea. If it is a good idea, the next step is to get it to work reliably at the lowest cost. Some investors[24] use technologists as hired guns. They engage a technologist to make a quick assessment to tell them whether or not an idea will work, and then they send them away. In our opinion, that's not a good strategy. If we hire technologists simply to answer questions one at a time, we have to pay each of them to educate themselves or to relearn earlier information. By putting them on the innovation team to begin with, they have the benefit of the entire story and can provide much better and coherent information and assessments. In addition, if they are enthralled with the idea, we can probably get them to work for a piece of the action rather than for a high hourly consulting fee. There is also much better assurance of confidentiality. Not that they would violate their legally binding confidence pledge, but if they understood the full picture, they would be less likely to make an inadvertent slip.

Some technologists can have an early vested interest as a coinventor or part-investor. Such involvement is subordinate to the primary role of technology assessor and developer.[25] It is expected that the technologist is the most objective of all the interested parties. The inclusion on a team of a specific technologist should be made with such an expectation, and it should be nurtured throughout the entire development and commercialization process.

Development-Oriented Our experience is that if the technologist is convinced that an idea is a blockbuster, we can tempt the person into working for nothing, because the very good ones are driven by the thrill of the chase.[26] They love to figure out ways to make things work better and

[24]For this book, venture capitalists and angel investors are subgroups of the investor category.

[25]Recall that we said earlier that there can be shifting back and forth and across the various roles and personalities of the innovation team.

[26]Unfortunately, food, college education, housing, and the like, get in the way of that approach.

at lower cost. The team has to be careful that the technologist does not allow enthusiasm to dim his or her objectivity. A technologist can be so caught up in development as to lose sight of the critical role of looking for pitfalls and avoiding them before they occur.

A favorable relationship between the technologist and the inventor/innovator is crucial for overall success. In our experience, initial encounters are rocky. The inventor views the technologist as an interloper, and the technologist can't understand how a crackpot like the inventor could possibly get anything done without help. But when the team starts to roll, things usually settle down and grudging acceptance turns into mutual respect. Positive moves must be made by the innovation team to help it happen soon after the two people are thrown together. However, care must be taken that the two parties don't go overboard and become too chummy. The last thing in the world that we need is for them to form a cabal that regards the investor and the entrepreneur as the enemy.

Key attributes of the technologist in the development process are imagination, project discipline, and a willingness to meld the ideas of others, not only the purely technical ideas but also those that touch on operating, financial, marketing, and sales issues. Project discipline refers mainly to maintaining the schedules agreed upon in project planning and to living within the budget.

Interested in Improvements and Ease of Operation The role of the technologist is not simply a technical one.[27] The technologist must be able to visualize the idea or concept in terms of its overall feasibility in the short term and its market potential in the long term. In other words, will it work, and will it sell? Moreover, these diverse judgments must be made in condensed time frames. Academicians (especially in consulting assignments) tend to draw out evaluation processes, leading to increased costs and often missed opportunities. Technologists have no time to fiddle. Very experienced and accomplished technologists are much like talent scouts for upcoming stars in the arts or sports. They can pick winners in a timely way because of their experience and knowledge of the business.

In addition, they approach evaluation with an eye toward improving on the original idea.[28] They try to visualize the potential of incorporating improvements that will make a product work better, cost less, and function

[27]In fact, the best technologists have good common sense and experience in a broad array of areas, including finance, accounting, marketing, operations, and maintenance.

[28]Remember how Mozart vastly improved Salieri's little tune of greeting in the film *Amadeus*?

reliably. Other primary goals are to make the product easy to build and easy to fix. As mentioned earlier, this penchant to improve on an original idea frequently brings them into conflict with the inventor/innovator. Technologists must strive to incorporate improvements with diplomacy and in collaboration with the inventor rather than in an antagonistic atmosphere.

The technologist will get no argument from the inventor in another facet of their respective roles: protecting proprietary rights. The technologist must try to make a product easy to build, operate, and fix but must also make it difficult for others to copy or steal the idea. There are several weapons in the arsenal, including patent protection, trade secrets, and continuing updates.

Interested in Cost Optimization Inventors/innovators often are poor estimators of what it will cost to bring an idea into practice. In part, this is because inventors believe that their ideas are the best thing since sliced bread and that the value is so obvious that commercialization will flow smoothly. Hence, the technologist is the personality that has to bring budget realism to the commercialization process. They must understand the basis of the concept in detail and have an unbiased view of what it will cost to commercialize. This includes making estimates of costs for technology assessment and evaluation, prototype development (bench scale, beta tests, pilot plants, semiworks, and other development stages), and full-scale production.[29]

Commensurate with their role as cost estimators, technologists are the primary planners of how to step through each of the stages enumerated above that comprise the various phases of development and commercialization. They need to be good communicators (in lay terms) of the implications of each stage. Additionally, they are the best arbiters and liaisons among the innovation team members because they are the ones who are obliged to remain the most objective in decision making.[30] To ensure that technologists behave objectively, the team could place monetary incentives on them to encourage this conduct.

Training-Oriented As commercialization progresses, new people will be hired to perform a broad variety of assignments. For them to do their jobs well, they have to be trained properly. Clearly, the technologist is best suited for this role.

[29]Although primary responsibility for marketing, sales, advertising, staffing, and related management functions is that of the entrepreneur, all other members of the innovation team, including technologists, must be consulted on establishing these budgetary items.

[30]This is the ideal situation, but just like everyone else, technologists get very emotional when things don't go their way.

Focused on Operations and Maintenance Although inventors can be valuable resources in designing and implementing operations and maintenance procedures, ultimate responsibility for establishing, executing, and monitoring these procedures resides with the technologist.

Bringing It All Together: Charles Steinmetz the Technologist

As self-described technologists, the authors look across the panorama of history and see many talented and innovative people who are excellent examples of technologists, but perhaps the first and arguably the best modern-day technologist was Charles Proteus Steinmetz. Most famous for inventing the alternating-current motor, Steinmetz was a multifaceted

FIGURE 1.4 Charles Steinmetz (right) and Thomas Edison at Steinmetz's laboratory at the General Electric Company in 1922. (Courtesy of the American Institute of Physics—*Emilio Segré Visual Archives.*)

genius whose contributions to the field of electrical engineering redefined the study of electricity and powered the world.

Steinmetz was a brilliant engineer who readily demonstrated the attributes we believe are intrinsic to technologists. Steinmetz was focused on new technologies and attracted to new inventions. For example, shortly after emigrating to the United States in 1889, Steinmetz found work under Rudolph Eickenmeyer, a Yonkers-based hat manufacturer who wanted to expand his business into electrical generators and motors. When Otis needed a more powerful motor to lift his elevator to higher floors, Steinmetz designed the motor. When Stephen Field, nephew of Cyrus Field of Atlantic Cable fame, approached Eickenmeyer with a proposal to run trolley cars by electricity using alternating current, Steinmetz was called upon. When the transfer from direct current to alternating current was made, there was a slight delay: slight, but long enough to cause motors to overheat. Working in Eickenmeyer's laboratory and at his residence at 124 Waverly Street in Yonkers, Steinmetz solved the problem mathematically and his solution became known as the law of hysteresis or Steinmetz's law. This now-famous discovery remains one of the bedrocks of electrical engineering study.[31]

Steinmetz was also a practical man—another hallmark of the technologist. For him, discovering new technologies wasn't good enough; they had to be useful and cost-effective. Continuing his investigation into electricity generation, Steinmetz discovered a practical means of calculating alternating-current circuits so that the performance of the system could be predicted in advance (without having to build the system and then go through expensive testing and modification). This discovery fueled rapid development and fielding of an electrical infrastructure that is considered one of the bedrocks of modern society. Steinmetz considered this one of his most profound contributions to science.[32]

Technically brilliant on a wide range of subjects, Steinmetz was called upon to fix or improve other designs. Hired at General Electric by Thomas Edison, he was instrumental in creating the company's proposal to develop generators at the new Niagara Falls power station. Steinmetz was made head of GE's Schenectady, New York calculating department, where his work led to the development of numerous transformational capabilities, including devices to protect high-power lines from lightning strikes,

[31] http://en.wikipedia.org/wiki/Charles_Proteus_Steinmetz. Also see a superior description of the development of Steinmetz's law at http://www.yonkershistory.org/stein.html.

[32] www.geocities.com/bioelectrochemistry.com/index.htm and search for Steinmetz. There are many other sources that give similar descriptions of Steinmetz's accomplishments, including http://www.encyclopedia.com/doc/1E1-Steinmetz.html.

high-powered traveling-wave tubes (which enabled later development of modern devices such as radar and microwave ovens), and arc lighting.

Recipient of nearly 200 patents, Steinmetz's prowess as a technologist is legendary, but one story stands out and is worth retelling. Told by Charles M. Vest, president of the Massachusetts Institute of Technology, during commencement on June 4, 1999, it showcases one attribute of a technologist.

> I want to tell you a story about an incident in the career of Charles Proteus Steinmetz, the great electrical engineer. In the early years of this century, Steinmetz was brought to General Electric's facilities in Schenectady, New York. GE had encountered a performance problem with one of their huge electrical generators and had been absolutely unable to correct it. Steinmetz, a genius in his understanding of electromagnetic phenomena, was brought in as a consultant—not a very common occurrence in those days, as it would be now. Steinmetz also found the problem difficult to diagnose, but for some days he closeted himself with the generator, its engineering drawings, paper and pencil. At the end of this period, he emerged, confident that he knew how to correct the problem. After he departed, GE's engineers found a large "X" marked with chalk on the side of the generator casing. There also was a note instructing them to cut the casing open at that location and remove so many turns of wire from the stator. The generator would then function properly. And indeed it did. Steinmetz was asked what his fee would be. Having no idea in the world what was appropriate, he replied with the absolutely unheard of answer that his fee was $1000. Stunned, the GE bureaucracy then required him to submit a formally itemized invoice. They soon received it. It included two items: 1. Marking chalk "X" on side of generator: $1. 2. Knowing where to mark chalk "X": $999.[33]

1.2.4 The Entrepreneur

The entrepreneur is the quarterback on the innovation team: the glue that holds the team together and inspires the members to achieve success. Entrepreneurs are the motivators and the people who make the whole thing happen. Often, the entrepreneur starts out in one of the other roles, eventually morphing into the force that the team relies on to move toward commercialization. Sometimes an entrepreneur will attempt to keep the other role at the same time, but in our experience, assuming two jobs at the same time doesn't work. Another analogy is that entrepreneurs

[33] Ibid. See also http://inventors.about.com/od/astartinventions/a/Steinmetz.htm for a similar description.

are like orchestra conductors. True maestros extract the best from skilled musicians, converting creative compositions into beautiful music.

Success-Oriented Just as with all of the other innovation team members, entrepreneurs are a different breed. They are single-minded and driven people, characterized by high energy levels, eclectic intellectual tastes, and most of all, the quest for success. For them, success is defined very individualistically. A common definition is that success = achievement = recognition. Sometimes power is more important than recognition, and more rarely, money is the ultimate goal of their achievement, but in our experience, not often. In short, "winning the game" frequently is the reward the entrepreneur seeks, with riches being a welcome benefit. A complementary characteristic of this success-driven personality is sociability. Entrepreneurs are gregarious and like to interact with others. This is what makes them good quarterbacks and great salespeople, without whom commercialization simply cannot happen.

Blends Other Perspectives Entrepreneurs are good at helping an innovation team to work together because they have the ability to blend the roles and duties of the other players. Moreover, the really good ones can even assume one or more of the other roles. But it is highly unlikely that entrepreneurs will be successful if they try to do too much themselves. The best entrepreneurs understand thoroughly the personalities, strengths, duties, and responsibilities of other team members, know who the outside experts are, and know when to use these experts to reach the commercialization process goals. This means that they cannot have a superficial understanding of any aspects of the idea or concept or of commercialization. They must have in-depth knowledge of how a concept works and how to sell it.

Keeps Focused Chances are that the entrepreneur has been successful before, so this idea will not be the person's only shot at success. In fact, being successful before probably is one of the reasons that he or she continues to gravitate toward this role. Prior experience helps the process, but it also prompts weakness. Once the person is convinced that the plan is sound and that the right team is in place, he or she may get eager to move on to the next idea. This can be a blessing or a curse. Entrepreneurs tend not to micromanage (good), but sometimes they become inattentive (bad). Keeping entrepreneurs focused clearly is a big challenge for the other players. Remember, we said that the commercialization process needs a great salesperson, and if the entrepreneur begins to believe that the idea will sell itself, trouble is brewing.

Money Isn't Everything We alluded to it earlier: Most entrepreneurs don't get their kicks by making money. Because of this characteristic and their success orientation and the fact that they define success in varied ways, entrepreneurs need to be backed up by a good and persistent accountant. Even though entrepreneurs understand the need for fiscal responsibility, they often need a strong reminder. Usually, this reminder comes from the investor, who probably chose the accountant in the first place. We said it earlier—money is not the only measure of success, but it is the best and most objective way to keep score and track of where we are along the way.

Rebel with a Cause: Steve Jobs the Entrepreneur

Few people have such a profound impact on society that people around the globe change the way they do things completely without thinking about it. As I sit here typing on my portable computer listening to my iPod after watching a movie rife with computer-generated animation, I cannot help but marvel at the development of these devices during my lifetime. But upon reflection, I realize that these devices weren't developed during the course of my lifetime. In fact, they are relatively recent developments spurred by the energy and determination of a focused entrepreneur. Steve Jobs has changed the world through his relentless pursuit of valued technology in the hands of the masses.

Like technical wizard and fellow entrepreneur Bill Gates, Jobs is a college dropout whose impatience with academics led to a broader life journey. A high school computer junkie, after leaving college he traveled to India on a journey of self-discovery only to return several months later fueled with a passion to develop and market affordable and functional computers for widespread use.

While still a high school student, he worked as a programmer at Hewlett-Packard, where he met and befriended Steve Wozniak, a technical genius. After an unsatisfying semester at Reed College in Oregon, Jobs returned to California and reunited with Wozniak at Atari, where they worked together as programmers. Soon Jobs realized that the two could do better on their own. Armed with Wozniak's ability to design and build computers and his own superior computer programming and business savvy, Jobs and Wozniak left Atari and formed the Apple Computer Company.[34] Soon the Apple computer splashed onto the world market with

[34]http://en.wikipedia.org/wiki/Steve_Jobs.

such innovations as the mouse pointing device and the point-and-click window presentation. Were these truly innovations? No. Invented elsewhere, they were integrated by Wozniak into a unique and easy-to-use platform, and Jobs brilliantly built a team to manufacture and market them around the globe.

With Wozniak quietly leading technical development, the success-oriented Jobs rapidly grew the ground-breaking computer business, matching it against industry juggernauts such as IBM. The Apple was a success on many levels and the company grew quickly. Jobs, realizing that he lacked experience managing such a large company, brought in John Sculley, an experienced Pepsico executive, as chief operating officer. Following the initial success of the Apple, the company followed with the Macintosh, with the brash Jobs pushing to expand the company's development efforts into other product lines. His blunt and aggressive approach, combined with sales figures that did not meet levels forecast, soon brought him into conflict with members of his board. Soon, the board forced him from the company and he left to create his own computer company, called NeXT.[35]

While at NeXT, Jobs sought to create powerful computers that featured creative capabilities not available in his competitors' systems. Although not a widespread commercial success in terms of sales volume, NeXT computers are regarded as one of the most capable and dynamic desktop devices ever built. Even though NeXT systems were the face of Steve Jobs' product line, Jobs was building a dynamo that would forever change the way we view entertainment.

Jobs' brilliance as an entrepreneur is highlighted by his ability to blend differing perspectives and fuse them into winning teams. During his period at NeXT, the company acquired a computer animation spin-off from *Star Wars'* creator George Lucas's studios and renamed it Pixar Animation Studios: creators of animated movies such as *Toy Story*, *A Bug's Life*, *Finding Nemo*, and *Cars*, and affiliated with the huge Disney entertainment empire. This transformation launched Jobs into the entertainment market with an enormous bang. When NeXT was acquired by Apple, Jobs found himself back at the company he founded, and he resurrected it. He led development of the iPod portable music system and the iTunes Internet-based digital music store, which forever transformed how the world acquires and listens to music.

An entrepreneur is defined as a person who organizes and manages any enterprise, especially a business, usually with considerable initiative and risk.[36] Steve Jobs has demonstrated—and continues to demonstrate—the

[35]http://ei.cs.vt.edu/~history/Jobs.html.

[36]http://dictionary.reference.com/search?r=2&q=Entrepreneur.

attributes the authors believe epitomize those of an entrepreneur. However you view him, he is an American classic!

1.2.5 Managing Innovation Team Interactions

Forming a team of headstrong, intelligent, ambitious, and driven individual members who have diverse experiences, educations, and backgrounds is a daunting task. But the key factor that will bind them and hold them together is what they all hate most. They hate to lose, and unless they agree upon certain "rules of engagement," they indeed will lose. Here are some rules that the team should consider seriously.

- The entrepreneur should be the chief operating officer. For day-to-day decisions, the entrepreneur is in charge and other team members should accept the entrepreneur's direction and leadership.
- The investor (or designated lead investor, if there are many) should be chairman of the board. In the event that a final decision must be made on a critical matter where the team does not reach consensus, the lead investor is the final authority. He or she is the ultimate boss, for the obvious reason that he or she is funding the enterprise.
- No money should be spent without the knowledge and concurrence of the entire innovation team. Authority can be granted in advance for certain ordinary expenses, but the team needs to meet for decisions regarding really large expenditures.
- Formal agreements should be in place for each team member so that there is a clear understanding of what happens if one member needs to be replaced or if the team needs to be dissolved.
- Secrecy and confidentiality agreements are essential and must be required of each team member. Moreover, these agreements must be strictly enforced.
- Contracts and agreements taken together should be regarded as a "covenant": both legally and morally.

Recognize that innovation team boundaries, particularly when first seeing a new concept, tend to be fuzzy. Measures should be taken to create rules that help to foster the creativity that emanates from this fuzziness rather than to build bureaucracy that strangles the enthusiasm of people who work better as friends than as competitors.

1.3 THE IMPORTANCE OF FLEXIBILITY

In the U.S. Air Force (USAF), one of the doctrinal tenets is: "Flexibility is the key to airpower." Some jokingly say that it is also the sign of poor or incomplete planning. Nonetheless, the culture of the USAF incorporates flexibility as part of the planning process. Being prepared for multiple contingencies is an important part of planning for success. General Dwight D. Eisenhower said that "no plan survives first contact with the enemy." He was right. Flexibility gives you the strength to persevere and survive obstacles.

For this book we suggest the following cautionary remark: "To be successful in commercialization, stay loose, but be disciplined." When we say "stay loose," we mean remain flexible. Flexibility is necessary because the terrain of exploiting technology changes so quickly that the innovation team has to be in a position of deciding intelligently what to do next many times throughout the commercialization process, often in rapid succession. Thus, the team has to be prepared for change by anticipating it in their business plan and having alternative pathways identified for the various contingencies.

The need for flexibility depends on a number of factors:

- Timing
- Status of the idea
- Technical needs and requirements
- Financial needs and requirements
- Pace of progress
- Target audience or customer

We deal with each of these factors in this section and address most of them again later in the book.

1.3.1 Timing Is Everything

In his insightful editorial entitled, "The Rules of Innovation," Jason Pontin suggests the following rule of innovation: "*The first attempt to commercialize an invention almost never succeeds*"[37] (emphasis added). Pontin reports that this rule emanated from a luncheon discussion that he had with John McAfee, founder of the anti-virus company McAfee Associates. Pontin says: "There are two reasons for this. First, the innovator

[37]Jason Pontin, "From the Editor: The rules of innovation," *Technology Review*, May 2005, p. 12.

is often early: the really important market for the invention does not yet exist. Second (the point is related), the innovator doesn't know how to make money from the invention: the business model that will support the invention is imperfectly understood. Usually, therefore, another organization succeeds where the innovator failed. This is sometimes called the Second-Mover Advantage."[38,39]

Two critical points are implied: (1) timing is extremely important in the commercialization process, and (2) effective planning could reveal fatal flaws in constructing a business model to exploit the innovation. Fortunately, many inventors/innovators don't believe that the rule pertains to them, so they press on and successfully become part of an innovation team that is, for all intents and purposes, the second-mover. Thus, whereas the rule has currency if participants hew to a "go it alone" approach, arranging to associate with others and building an innovation team can overcome the pitfalls of being too early and not knowing how to commercialize the idea.

Nevertheless, it is possible to be too early. In the same editorial, Pontin articulates another rule of technological innovation: *"Any sufficiently radical invention seems ridiculous to most people when they first encounter it"* (emphasis added). Time has to be allowed to permit the innovation to gestate in the minds of both the inventor and the customer. But clearly, the inventor's job is to envision how to refine the idea into a marketable product before the concept can be sold to the customer or even to other members of the innovation team.

The issue of timing is tricky. Dawdling can be a greater sin than premature introduction of a good idea. Hence, balance has to be sought in exploiting the idea. That's why we are proponents of the innovation team approach. Each of the core members of the team (i.e., inventor/innovator, investor, technologist, and entrepreneur) will lend his or her expertise to assessing the impact that timing can have. Even very good teams can get ahead of themselves. An example of this is the huge and greatly underutilized fiber-optics network into which many high-tech companies

[38]Ibid.

[39]*Technology Review, MIT's Magazine of Innovation*, claims to be the oldest technology magazine in the world. "Founded in 1899, *Technology Review* describes emerging technologies and analyzes their commercial, economic, social, and political impact for an audience of senior executives, researchers, financiers, and policymakers, as well as for the MIT alumni. In addition, Technology Review, Inc. produces technologyreview.com, a Website that offers daily news and opinion on emerging technologies." We urge readers of this book to use this invaluable resource not only to assess technologies of particular interest to them, but also to learn how others have approached the process of commercialization. We have read the magazine for many years and have reflected the knowledge gained at many places throughout this book.

sunk immense capital in the middle to late 1990s. Occasionally, participants should slow down to permit technological horizons to come into view.

During the 1990s, facing the forecast of tremendous bandwidth demand in the inflated dot.com economy, several telecommunications companies invested heavily in the installation of massive fiber-optic cable networks around the United States. These fiber-optic builders were desperately afraid that their competitors would beat them to customers. The resulting mass installations yielded an incredibly robust fiber-optic capability in portions of the United States, but the market did not materialize as anticipated. As of this writing, much of the fiber remains "dark fiber," excess capacity that is not used and hence is not drawing revenue for investors.

One way to strike a reasonable and rational balance between haste and excessive deliberation is what we call the *bullpen*, *holding tank*, or *reserve box*.[40] If, in the process of evaluating ideas, the innovation team believes that a very good idea may be premature, it is put into a mode (i.e., the bullpen) where development of the idea moves forward, but at a more measured pace. In that way inventors and technologists don't forget about the idea completely and move on to other things. They remain in touch with the leading edge of the state of the art, continue to network with others in the field, and proceed with a more thoughtful and less frenetic pace of development. Should events come into better focus and dictate rapid ramping up, the team should be in a position to do so quickly. The entrepreneur, as quarterback and visionary, plays a key role in deciding the pace of development (see Section 1.3.5).

The ability to shift gears depends on a good, sound plan of action from the outset. The plan must be characterized by deliberate preparation and crisp decision making. We address the various elements of planning in later sections. But at this point we can summarize by saying that we can bring timing into control if we have a good idea, build an effective innovation team, and prepare and implement a thoughtful commercialization plan. The main reason for better control is that by having these elements in place, we are much less likely to be surprised.

In summary, here are the magic ingredients of knowing when and how fast to move forward with an idea: *timing, planning, insight*, and *luck*. Just a few words on luck; there are two great quotations on the subject that have special pertinence to our subject.

[40]One of the authors likes the term *bullpen* best. He says, "It is an idea that is still out there; all you have to do is warm it up." He makes an excellent point, and we will use that term.

"I find that the harder I work, the more luck I seem to have."—Thomas Jefferson

"Luck is the residue of design."—Branch Rickey

Together these quotes recognize the value of hard work and planning. In the event that we are sluggish in exploiting an idea, we don't give up. Because we have a plan, we can't be that far behind. So we don't give up, we just work hard to recover ground lost and make up the difference by improving on the quality and performance of the product. Finally, always remember that other people can be lucky, too.

1.3.2 The Importance of Determining "Prime Time"

The intensity with which the innovation team reacts to a concept depends to a large extent on how far along the idea is. If the idea is a barn-burner but is still a concept on paper, you react one way. Conversely, if it's in its fifth generation, you react in another way. The trick is in being able quickly to tell the difference between the two. Clearly, the technologist plays the most important role in making this determination.

Learning the technical status of an idea is crucial to the entrepreneur because the entrepreneur has to come up with the game plan for establishing an appropriate budget and schedule and the team has to make an early "go–no go" decision. This is not meant to imply that we are forced to shoot pennies out of the air, but it does mean that we have to match the rigor of moving ahead with the status of the idea. Careful understanding of the idea focuses on what's been done to date—both successes and failures. The innovation team, based on this understanding, basically decides three things: (1) if we will move ahead with the idea (i.e., go–no go), (2) how much we are going to have to spend, and (3) how long it will take to meet the first milestone.

In general, barn-burners generate a lot of enthusiasm, but there are a couple of obvious problems. First, usually a lot less is known about the idea. This is because hype and hope cloud the vision of those selling the idea, and the inventors/innovators get ahead of the facts. This makes the job of the technologist more difficult. Second, the enthusiasm could be premature. Remember Pontin's "first rule of innovation" (Section 1.3.1). Third, if it was all that great an idea and a lot is known about it, why is it still on the street? So clearly, dealing with barn-burners entails lots of risk, and caution must balance fervor. On the other hand, tired ideas that have been beaten to death take a long time to bury. We still see ideas that we passed up 35 years ago that somebody has reinvented and tried to breathe new life into.

Ideas can range anywhere from a nascent airburst of an idea that a brilliant innovator had in the shower this morning to one that we characterize as "the walking dead." Obviously, ideas can fall anywhere in the spectrum between the two. Recognize where along the line we are and act accordingly.

1.3.3 Expanding the Innovation Team

Let's assume that the innovation team decides that the timing for exploiting a good idea is on the money (every pun intended)—that is, *now*! Moreover, also assume that the idea is far enough along so that there is a sound base of technical information; that is, the status of the concept is at the point where spending money for development is appropriate. Here's where the innovation team, in this case led by the technologist, earns its keep. It takes real talent and is a precursor for success to be able to assess accurately the status of a concept and (here's the hard part) then define the technical needs and requirements to make it happen.

Frequently, this means that an imperfectly understood concept requires the services of people who can understand every aspect of the idea. That, in turn, means that often the team has to look outside for the right experts. It's not easy for many team members to call in the right experts at the right time. That's because it's hard for their egos to accept that they don't know everything. Oddly enough, it usually isn't the technologist who is unwilling to seek expert help. Technologists are more accustomed than the inventor/innovator to working in a more collegial environment and feel comfortable getting validation of their "brilliant" insights from their buddies. As we said earlier, the inventor/innovator at times thinks that everybody else is stupid because they can't grasp the "obvious." But it's the investors and the entrepreneurs who have the biggest case of indigestion with "experts" or "consultants." Some of their concerns are legitimate.

One concern reflects on the technologist. "If you are so smart, how come we continually have to use outsiders?" The answer is simple. Even in specific areas, experienced technologists need to understand in greater detail nuances that sometimes mean the difference between success and failure. What seems like nitpicking to investors and entrepreneurs is crucial to the technologist. Remember that the technologist is a valued member of the team not because he or she knows everything, but rather, knows how to get things done. Thus, the ability to identify the need for outside help and to find the right people who can fill that need is a real key to success.

Investors and entrepreneurs are correct to be concerned about letting too many people in on an idea. There are several specific concerns. First,

there is the potential for dilution of ownership, especially if the expert requires a piece of the action in addition to or in lieu of a fee. Second, revealing too much proprietary information puts the secrecy and confidentially of an idea at risk. Some team members can be particularly concerned if they regard the expert as a stranger. Third, what the innovation team doesn't need is another ego that will lead to personality clashes. Experience demonstrates that the person that the inventor likes least is an "outside consultant." Fourth, even if we've got a good consultant with whom everybody gets along and who is an effective resource, sometimes the person may leak insights to the concept that forces premature marketing and false starts.

One way to keep experts under control is to maintain a small stable of consultants and stick with that inner circle. If the scope of the concepts and ideas that the innovation team has chosen is not too broad-ranging, that approach may be possible. Another way is to trust in the innovation team's ability to work well with each other and their inherent talents, and not use outsiders. We prefer the former approach.

Despite the claims of the inventor, great ideas are not ready to walk at birth. They need a lot of refinement before they are ready for the marketplace. The process of determining the nature of that refinement is the essence of this section. Simply put, the ability to assess what the technical needs and requirements are that will make an idea or concept into a commercial success is absolutely crucial, and the talent to do so is managed initially by the technologist but ultimately depends on the genius of the entire innovation team.

Another excellent tactic that is used extensively today is *red teams*, peers to attack or look at our efforts from a different angle so that we can focus on the weaknesses in our position. It is a device that is used extensively to challenge and stretch opinions and work products. Keep in mind the need for confidentiality when picking a red team.

1.3.4 Determining How Much Money Is Needed

Once technical needs and requirements are determined, it's time to talk about money. It is essential that the innovation team toils carefully and collegially to make an accurate assessment of how long it will take and how much money it will cost to bring an idea into practice. We emphasize that the team has to undertake this effort with great focus and concentration because this step leads off the intensive planning and management regimen that makes the difference between success and failure.[41]

[41]Refer back to the list of key ingredients for successful commercialization.

All team members carry the same weight in this process.[42] Eventual resolution of budgets and schedules must be unanimous. There are many reasons why, but the main one is that in the course of commercialization, prolonged schedules and increased budgets are the norm. It's the nature of the beast that there will be changes and surprises. The last thing the team needs is somebody saying "I told you so!" Everybody on the innovation team must understand clearly that surprises (both good and bad) will occur and there will be a need to change the pathway. The ability to be flexible is absolutely essential to make an idea a commercial success. In summary, both the people and the plan they prepare must be flexible.

The real trick is to plan for change and to keep schedule and budget variances small. Time must be devoted to anticipating what the changes might be and developing alternatives to be implemented when these changes happen, as they invariably will. The alternatives should be viewed not as an addendum to the plan in case of trouble, but rather, as an integral part of the plan. In our experience (and we will say this more than once), the most unpleasant surprises occur when good things happen, not bad ones. That's because we often spend too much time figuring out what to do when things go wrong and not enough on what happens when we get lucky.

In addition, strong project discipline is necessary. It's a real challenge to stick to your knitting and proceed stepwise. The temptation at times to take shortcuts will be powerful, but in our experience, skipping over planned activities almost never works. Besides, it's stupid to expend time and effort to develop a detailed plan and then ignore it.

1.3.5 Maintaining a Reasonable Pace of Progress

The pace at which the commercialization process proceeds usually tests the tolerance of innovation team members to accept setbacks and delays. Their degree of flexibility or patience can vary considerably. That's no big surprise given the assorted perspectives that each team member brings to the project. For example, the investor wants to know how much more money will be needed. The entrepreneur wants to know how much longer it will take. The inventor wants to know when the technologist is going to stop fiddling and get moving ahead with dispatch, and the technologist wants everybody to stay calm and understand that progress is going along according to plan—more or less.

So what's the solution for keeping the team together without unduly challenging their patience? At the risk of being excessively repetitive, the

[42]Somebody has to lead this effort, and in this case as in most others, the entrepreneur will fulfill that role.

solution is the formulation of a solid, thoughtful, and flexible plan that anticipates deviations and takes them into account through development and inclusion of alternatives.

The innovation team should have formal progress reviews at regular intervals to keep everybody informed. If there are serious divergences not anticipated by alternatives in the plan, the plan must be updated. All team members have to play a part in these updates, just as they did in the original plan formulation. It is important to understand that these updates are needed periodically and must be addressed in a timely fashion.

1.3.6 Knowing the Customer

Typically, inventors/innovators, in their enthusiasm, believe that everyone wants what they have discovered. That can be a dangerous mind-set. iPods don't sell well to the hearing impaired, and some of us wouldn't play a videogame if you gave it to us. You have to know your market. The entrepreneur is the leader in keeping the team focused on the appropriate market, and sometimes development results can shift that focus dramatically.

One research and development project with which we were associated was charged with testing a naturally occurring ion-exchange mineral. Our project manager was distraught when he learned through experimentation that ion-exchange capacity was impaired severely by the presence of a competing ion commonly found in the solution he was testing. In an effort to calm him down, his office-mate asked about the process and why the interfering ion was able to decrease capacity. During the course of their discussion they came to the conclusion that they could make a lot more money by going after the competing ion than after their original target ions. Hence, they shifted gears and made a major positive impact on a wholly new market.

The point of this example is that the old mantra "know your customer" is extremely important, but sometimes opportunities will present themselves in a way that will cause you to see your technology from a completely different perspective. If you aren't flexible, you may miss the chance of a lifetime.

1.4 CAN ENTREPRENEURSHIP BE TAUGHT?

1.4.1 The Difference Between Talent and Skill

When we were writing this book, one of our extremely insightful friends raised the annoying question: Do you really believe that you can teach

people how to be entrepreneurs? His theory is that like leaders, athletes, musicians, and artists, among others, entrepreneurs are inherently talented and cannot be taught because their gifts are innate. By raising this issue, he questioned the usefulness of our book. As we debated his thesis, we agreed that there is an immense difference between "talent" and "skill," but ultimately, we concluded that practice, discipline, and knowledge are essential attributes (in addition to those listed earlier: teamwork, planning, and perseverance) in perfecting the natural talents of these unique people.[43] Thus, by focusing on these attributes, we believe that we can help to hone the abilities of readers who want to commercialize innovative technology or to understand how it's done.

Moreover, in our discussions with our good friend, we acknowledged that teaching a subject for purposes of greater understanding is useful for full appreciation of the gifts of talented people. For example, teaching music, painting, and sculpture doesn't make a person a Mozart, Rembrandt, or Houdon, but it does permit us to recognize great talent and appreciate how such creativity enriches our lives. Therefore, we concluded that entrepreneurship indeed is an innate talent, but our book fulfills a definite need for those who are eager to understand how good ideas are put into practice and how people work hard to make it happen.

1.4.2 Entrepreneurship Programs at Major Universities

When we started this book, we had only a vague idea of the extent of formal educational programs focused on entrepreneurship. We knew of the outstanding programs at MIT and Stanford but did not have a full appreciation of the breadth and depth of academic programs across the United States and globally. Clearly, the scope of university programs is important to us because it extends our prospective audience to a potentially large body of faculty and students interested in the commercialization of innovative technology.

We decided that we would explore how many of the leading graduate schools of engineering and business had formal programs devoted specifically to the subject of entrepreneurship. We used three lists of top schools to conduct our exploration: (1) *U.S. News and World Report's* (*USNWR*) "America's Best Graduate Schools 2007, Top Engineering Schools"; (2) *USNWR*, "Top Business Schools"; and (3) The *Wall Street Journal*, "Back on Top," September 21, 2005, a list of the world's top business schools. Then we chose the top 10 from each list; understandably, there were many

[43]Think of how important practice, discipline, and knowledge are to the fabulous golfer, Tiger Woods.

duplications. We added Rensselaer Polytechnic Institute to the list of engineering schools because the senior author spent more than 20 years on that institution's various advisory boards and councils, giving us unique insight into that university's capabilities. Because of limitations of time and space, we chose to confine the list to universities in the United States. Obviously, there are many great universities in other countries that have similar programs, and we don't mean to neglect them. We looked at four: IMD, Lausanne, Switzerland; ESADE, Barcelona, Spain: IPADE, Mexico City, Mexico; and University of Western Ontario, London, Canada. Each had intensive and thoughtful programs that promote the education of eager entrepreneurs.

Table 1.2 catalogs the U.S. universities that we investigated using the three lists above to learn what vehicles (centers) they had established for the study of entrepreneurship and innovation and to get a feel for the types of courses that are offered. Interestingly, of the 20 universities cited in Table 1.2, all but one had a formally designated center of excellence devoted to entrepreneurship, and all have strong programs in technology, innovation, and the management of new enterprises. Table 1.3 provides details on centers of entrepreneurship and courses taught on the subject.

Clearly, the best universities in the United States are seriously committed to educating budding entrepreneurs and to building awareness of the importance of launching new enterprises for the economic health of the nation. Thus, we conclude that there are many more programs than those that we identified in Tables 1.2 and 1.3. We conclude further that most of the programs are centered in graduate schools of business, although many business schools have included or are affiliated with engineering schools in some way.

The Ewing Marion Kauffman Foundation in Kansas City, Missouri, is dedicated to promoting entrepreneurship education. The foundation has published the *Census of the Status of Entrepreneurship in American Higher Education: 2006*. An article by Frank[44] summarizes some of the data from the *Census*.

- Entrepreneurship education is the fastest-growing field of study in 2006.
- During 2006, at least 300 four-year higher education institutions offered entrepreneurship courses designed for students *not* enrolled in business schools.
- More than 1600 colleges offered courses in entrepreneurship in 2006.

[44]J. A. Frank, "Ideas in action," *Rensselaer*, Fall 2006, pp. 18–23.

TABLE 1.2 Programs in Entrepreneurship at Top Universities in Engineering and Business

University	USNWR Engineering Rank	USNWR Business School Rank	WSJ Business School Rank
Cal-Berkeley	3	7	7
Cal Tech	10		
Carnegie Mellon	8		3
Chicago		6	
Columbia		7	8
Dartmouth		9	1
Georgia Tech	4		
Harvard		1	
Illinois	5		
Michigan	7		2
MIT	1	4	
North Carolina			9
Northwestern		4	4
Penn		3	6
Purdue	6		
Rensselaer	37		
Stanford	2	2	
UCLA		10	
USC	9		10
Yale			5

- About 1050 colleges offered entrepreneurship courses in the early 1990s.
- About 300 colleges offered entrepreneurship courses in the 1980s.

Thus, our conclusion about the scope of entrepreneurship education appears to be right on the mark: in fact, the data from the Kauffman *Census* came as a bit of a surprise, even to us. The enthusiasm of the academic community was confirmed during our recent participation in a National Science Foundation environmental engineering education workshop, where the professors attending were particularly vocal in their support of stimulating and implementing innovation in their curricula.[45]

[45]C. J. Touhill, "Entrepreneurship and technology commercialization," presented at the Workshop on Frontiers in Environmental Engineering Education, January 10, 2007, Tempe, Arizona. Sponsored by The National Science Foundation, the American Academy of Environmental Engineers, and the Association of Environmental Engineering and Science Professors.

TABLE 1.3 University Centers Are Courses in Entrepreneurship

University	Program/Center	Selected Courses	Notes
MIT	Deshpande Center for Technological Innovation and the MIT Entrepreneurship Center	Law for the Entrepreneur and Manager Managing the Innovation Process Managing Innovation: Emerging Trends Product Design and Development How to Develop "Breakthrough" Products and Services Global Entrepreneurship Lab Designing and Leading the Entrepreneurial Organization Entrepreneurial Finance Patents, Copyrights, and the Law of Intellectual Property Developmental Entrepreneurship Social Entrepreneurship Entrepreneurship/Venture Capital Without Borders Technology and Entrepreneurial Strategy	Courses offered through the Sloan School of Management

(*Continued*)

TABLE 1.3 *(Continued)*

University	Program/Center	Selected Courses	Notes
Stanford	Center for Entrepreneurial Studies	Investment Management and Entrepreneurial Finance Environmental Entrepreneurship Strategies and Practices of Family and Closely-Held Companies Entrepreneurial Design for Extreme Affordability Intellectual Property and Its Effect on Business Entrepreneurship: Formation of New Ventures Entrepreneurship and Venture Capital Evaluating Entrepreneurial Opportunities Social Entrepreneurship Strategic Management of Technology and Innovation	Courses offered through the Graduate School of Business

University of California–Berkeley	Center for Entrepreneurship and Technology	Engineering Entrepreneurship Entrepreneurial Marketing and Finance Distinguished Innovator Lecture Series	Associated with the College of Engineering; The College of Engineering offers a program that awards a Certificate in Management of Engineering and Innovation
	Lester Center for Entrepreneurship and Innovation	Organizational Leadership (multidisciplinary curriculum)	Associated with the Haas School of Business
Georgia Tech	**TI:GER** (Technological Innovation: Generating Economic Results)	Fundamentals of Innovation I & II Special Topics in Technology Commercialization Entrepreneurial Finance Innovation of Entrepreneur Behavior Venture Creation Corporate Entrepreneurship Legal Issues in Technology Transfer	College of Management offers a "Program for Engineering Entrepreneurship" leading to a Certificate in Engineering Entrepreneurship
University of Illinois–Champaign/ Urbana	Office of Business Innovation and Entrepreneurship	Small Business Consulting Entrepreneurship: Small Business Formation Financing Small Business Development	The College of Business offers concentration in entrepreneurship at the undergraduate level focusing on small business

(*Continued*)

TABLE 1.3 *(Continued)*

University	Program/Center	Selected Courses	Notes
Purdue	Burton D. Morgan Center for Entrepreneurship	Introduction to Entrepreneurship and Innovation Entrepreneurship and Innovation II	The Center offers undergraduate students in any major the opportunity to earn an Entrepreneurship and Innovation Certificate
University of Michigan–AnnArbor	Sam Zell and Robert H. Lurie Institute for Entrepreneurial Studies	Entrepreneurial Management Entrepreneurship via Management Venture Capital, Private Equity I & II Managing the Growth of New Ventures Marketing for Entrepreneurs Entrepreneurial Turnaround Management Legal Aspects of Entrepreneurship Writing Fundamentals for Entrepreneurs	Program is in the Ross School of Business

Carnegie Mellon	Ph.D. program in strategy, entrepreneurship, and technological change	Economics of Entrepreneurship Economics of Technological Change Courses in entrepreneurship, firm startups, and financing of new ventures Courses in engineering pertaining to innovation and technology Courses in technology policy and innovation	Joint program of the Social and Decision Sciences Department, Tepper School of Business, Heinz School of Public Policy and Management, and the Engineering and Public Policy Department
	Donald H. Jones Center for Entrepreneurship	Introduction to Entrepreneurship Entrepreneurial Thought and Action Funding Early Stage Ventures Commercialization of Technology in Entrepreneurial Companies Entrepreneurial Business Planning Entrepreneurial Management	Program is in the Tepper School of Business

(*Continued*)

TABLE 1.3 *(Continued)*

University	Program/Center	Selected Courses	Notes
University of Southern California	Lloyd Greif Center for Entrepreneurial Studies	Technology Feasibility Technology Commercialization Investing in New Ventures Management of Rapidly Growing Ventures Engineering Project Management Invention and Technology Development Strategic Management of Technology Strategies in High-Tech Businesses	Graduate Certificate in Technology Commercialization in the Marshall School of Business
Cal Tech		Engineering Entrepreneurship Management of Technology	No formal programs explicitly directed toward entrepreneurship or technology commercialization, but many opportunities to participate in new venture workshops and seminars in the Division of Engineering and Applied Science

Rensselaer	Severino Center for Technological Entrepreneurship	Entrepreneurial Finance Invention, Innovation, and Entrepreneurship Starting a New Venture Corporate Entrepreneurship Marketing High Tech Products R & D Management	Program is in the Lally School of Management and Technology
Harvard	Technology and Entrepreneurship Center at Harvard	Biotechnology Startup Introduction to Biotechnology Innovation in Science and Engineering: Conference Course	
	Arthur Rock Center for Entrepreneurship	The Entrepreneurial Manager Entrepreneurial Finance Entrepreneurial Marketing Managing for Creativity Building and Sustaining a Successful Enterprise Leading Innovation, Change and Organizational Renewal Entrepreneurship and Global Capitalism International Entrepreneurship Managing Innovation and Product Development Commercializing Science and High Technology Evaluating the Entrepreneurial Opportunity	Center at Harvard Business School (partial list of courses)

(*Continued*)

TABLE 1.3 *(Continued)*

University	Program/Center	Selected Courses	Notes
Penn	Sol C. Snider Entrepreneurial Research Center	—	Home of research for Wharton Entrepreneurial Programs, it is the first center dedicated to the study of entrepreneurship
	Goergen Entrepreneurial Management Program	Technology Strategy Entrepreneurship Change, Innovation and Entrepreneurship Venture Capital and Entrepreneurial Management Formation and Implementation of Entrepreneurial Ventures Private Equity in Emerging Markets Entrepreneurship Through Acquisitions	Wharton School of Business
	Minor in Engineering Entrepreneurship	Engineering Entrepreneurship I and II High-Tech Venture Development Ideas to Assets From Laboratory to Marketplace	Offered in the School of Engineering and Applied Science

Northwestern	Larry and Carol Levy Institute for Entrepreneurial Practice	Successful Entrepreneurship Entrepreneurship and New Venture Formulation Entrepreneurial Selling Understanding and Managing Risk Entrepreneurial Finance Managing Technology Technology Marketing Internet Marketing	Offered at the Kellogg School Entrepreneurship and Innovation Program
Chicago	Polsky Center for Entrepreneurship	Entrepreneurial Finance and Private Equity New Venture Strategy Building the New Venture Commercializing Innovation Developing New Products and Services Technology Strategy Structuring Venture Capital and Entrepreneurial Transactions Statistical Insight into Marketing Consulting and Entrepreneurship	Offered in the Graduate School of Business
Dartmouth	Center for Private Equity and Entrepreneurship	Introduction to Entrepreneurship Private Equity Finance Advanced Entrepreneurship Entrepreneurial Management Growth Strategies of Emerging Enterprises	Offered in the Tuck School of Business

(*Continued*)

TABLE 1.3 *(Continued)*

University	Program/Center	Selected Courses	Notes
UCLA	Harold Price Center for Entrepreneurial Studies	Managing Entrepreneurial Operations Managing Finance and Financing the Emerging Enterprise Law for Entrepreneurs Technology Management	Offered in the Anderson School of Management
Yale	(No formal center)	Entrepreneurial Business Planning Venture Capital and Private Equity Investment SynThesis: Product Design for Entrepreneurial Teams	Offered in the Yale School of Management
Columbia	Eugene M. Lang Center for Entrepreneurship	Introduction to Venturing Entrepreneurial Finance Launching New Ventures Entrepreneurship and Private Equity in Emerging Markets Technology Strategy Business Technology and Innovation Entrepreneurial Selling High Technology Marketing and Entrepreneurship New Product Development Law for Managers and Entrepreneurs	Offered in the Columbia Business School

North Carolina	Center for Entrepreneurial Studies	Introduction to Entrepreneurship Business Plan Creation Venture Capital Management Entrepreneurial Marketing Innovation and Product Development Managing in the High Tech Sector VC Valuation and Deal Structure Acquiring Proprietary Technology Launching the Venture I & II Mergers and Acquisitions	Offered in the Kenan– Flagler Business School

1.4.3 Corporate Research and Development Programs

People who sell computers, pharmaceuticals, medical devices, automobiles, and razor blades spend billions of dollars every year to find innovations that will keep their companies growing and profitable. Is this spending comparable to the commercialization process we describe in this book? The answer is generally "no." Virtually all of these companies are large, with significant research and development budgets that support laboratories dedicated to a disciplined process of extending and expanding the scope of company products. Commercialization is built in at each stage of product development. So whereas there are aspects of corporate research and development (R&D) that could be helpful to budding entrepreneurs, reading up on drug company R&D isn't going to help Johnnie Inventor sell his new light bulb that will last forever. But we like to believe that our book can be a significant help.

Before we leave this topic, we'd like to mention a couple of ways that some companies that have "formal" research/commercialization programs get into trouble. First, in an effort to stimulate creative employees to come up with innovative ideas, companies establish budgets to encourage and fund such endeavors. In many cases, managers have good employees who aren't fully billable at the moment, so the R&D fund becomes a "slush fund" and is used to tide the employee over until a real project comes along.

Second, one of the world's leading research contractors many years ago provided an early investment into an innovation that became a booming success. In an effort to reproduce this great achievement, they formed a subsidiary organization with profits made in the original success. The intent was to attract outside inventors and in-house scientists and engineers who would develop new ideas and share in the commercial success with the research contractor. Unfortunately, for over 60 years they have been unable even to come close to the original boon. There are several problems: They failed to acknowledge that their first find was lucky, and they never set up a system that would work. The system they used was very bureaucratic. They wanted too much ownership in the eyes of internal and outside inventors,[46] and it eventually degraded into a sort of slush fund, as described above.

Finally, those of us who have served on SBIR/STTR review panels have learned pretty quickly that there are many proposers whose names turn up time after time. These are proposal mills, whose primary *raison d'être* is cranking out SBIR/STTR proposals, not necessarily the commercialization

[46]The system was so bad and burdensome for insiders that anybody who had a really good idea simply quit and sought his or her own investor capital.

of good ideas. A characteristic of such companies are jazzy proposals on such hot topics as nanotechnology, biotechnology, and homeland security. Their proposals often are very well done, and their boilerplate on the subject of commercialization is satisfactory, if vague, but if their record of commercializing previous innovations is a measure of success, they don't do very well. The problem is that they are really more interested in SBIR/STTR funding than they are in the commercialization of new technology.

1.5 KEY POINTS

- This book is intended to provide insight for those who are eager to commercialize good ideas and concepts. It can serve as an inventor/innovator manual, a university textbook, an SBIR/STTR reference, or a technology investment handbook. It will also be helpful to business executives and management students in explaining the life cycle of product innovation and the dynamics of bringing good ideas to the marketplace.
- The four key ingredients that make commercialization of good ideas successful are teamwork, planning, discipline, and perseverance.
- Building an innovation team is crucial to the process of bringing good ideas into practice. The innovation team best equipped to commercialize technology is one comprised of four distinct personalities: inventor/innovator, investor, technologist, and entrepreneur.
- To build a successful innovation team, the mind-set of each personality or role must be thoroughly understood.
- Profiles of famous people who embody the best characteristics of the roles of inventor/innovator, investor, technologist, and entrepreneur are included in this chapter as brief vignettes.
- Flexibility is crucial because the terrain of exploiting technology changes quickly. To prepare for change, the innovation team has to anticipate it in the business plan and have alternative pathways identified for various contingencies. The need for flexibility depends on a number of factors: timing, status of the idea, technical needs and requirements, financial needs and requirements, pace of progress, and target audience or customer.
- Virtually every major technological university and business school has a formal center and academic program that promotes and teaches entrepreneurship.