1

The Role and the Challenge

What is engineering project management? Why do we teach engineering project management? Do engineering projects matter to society? Do engineering projects matter to business? What is a "project?" What is an "engineering project?" What is a "project manager?" In this chapter, we discuss all of these questions and also provide you basic information about the role of engineering project manager and the opportunity that this role represents for you.

1.1 Introduction

In this book, we study the subject of *engineering project management*. Let's look carefully at the first two of those three words:

- "Project." By this word, we mean a deliberatelyundertaken endeavor to create something that we believe will be of value. This desired result might be a tangible artifact ("product"), or it might be a service. We might plan to use it ourselves, or we might be planning to offer it for sale.
- "Engineering project." By adding the modifier "engineering," we now indicate that the methods we will use to create this result involve "engineering." By this, we mean the methods that we will use depend significantly on the application of technology and technological concepts in order to achieve a practical effect. Other disciplines – such as finance, science, art, and so forth – may also be made use of in order to create our desired product or service, but by identifying this as an "engineering project," we are indicating that we consider the role played by the application technology and technological concepts to be *central to the success of the project*.

The judgment about whether the role of technology and technological concepts is central to a project is sometimes fairly obvious (e.g., designing a new computer processor microchip), but in other cases, it may be more subtle. For example, painting in oils on canvas involves quite a lot of technology; someone has to know how to create the paints, someone has to figure out what methods of preparing the canvas are likely to create a surface to which the paint will adhere well, and so forth. These are highly technological subjects! But since those technologies have *already* been worked out, and can today be made available in a form that allows the paint and the canvas to be used in a manner that requires only minimal knowledge of the underlying technology, we probably would no longer consider creating an oil painting an engineering project. This is because, while painters must learn the technique for preparing a canvas, and for applying the paint, they generally no longer have to learn how to do the underlying technological work, such as creating the paint, and no longer have to understand how certain materials in the paint result

Engineering Project Management: A Hands-On Guide for Successful Engineering Projects,
Second Edition. Neil G. Siegel.

Companion website: www.wiley.com/go/siegel/engineering_project_management

in certain properties for the paint. There was certainly a time (a few hundred years ago), before these technologies had been worked out, that one could properly have considered painting in oils on canvas an engineering project. But by now, these technologies have matured to a point where a non-technologist can *apply* them by learning a *technique*; the artist need not know the underlying technologies. Given the maturity of these technologies, and their availability in a form that non-technologists can learn to use, we would probably consider that the creation of technology is no longer central to the success of our oil-painting project, and therefore, today we would likely not consider painting in oils on canvas an engineering project.

This is akin to the difference between *operating* a car or a computer and *designing* a car or a computer. Operating the car or the computer requires technique, but does not require detailed knowledge of the underlying technology.

Now, let's add our third word:

- "Engineering project management." By adding this third word, we have moved from focusing on the desired end result (that is, the product or service that we intend to create) to focusing on the *process and method by which we will create it.* By *management*, herein we mean the notion of planning and organizing the activities that will create the desired end-product or service – e.g., things that are done *before* we start the actual project. It has the additional connotation of providing leadership to that activity while the effort is underway – e.g., things that are done *during* the conduct of the actual project, for which we often use words such as *performing* (e.g., doing the actual work, in accordance with the planned methods), and *monitoring* (e.g., making sure that we are following the intended methods, and also measuring in some quantifiable manner "how we are doing: are we progressing as expected?").

Engineering project management is therefore a discipline that provides the methods and discipline to get to our desired result: that product or service that we want to use or offer for sale, where the application of technology or technological concepts is central to the eventual success of the project.

1.1.1 Why Do We Care About Engineering Project Management?

I will start this part of the story with two assertions:

1. Engineering projects are vital for society.
2. Engineering projects are "of the essence" to business – they are the *only* source of revenue for many companies – and the creator of new methods and new products for almost every organization (business, government, nonprofit, etc.).

There is a third assertion, too:

3. Being the manager of an engineering project is a *great* job!

Let's discuss each of these three assertions.

Here's a little warm-up exercise: in your opinion, what is the most important human accomplishment of the last 2,000 years? Think about it for a moment, and write down a phrase describing your answer.

Your answer:

When I ask this question on the first day of my engineering project management courses, I get lots of really good and interesting answers. Obviously, this is a matter of opinion, and we can all have an opinion. But here is my answer:

> The most important human accomplishment of the last 2,000 years is the doubling of the average length of human life.

What the archaeologists and other scientists who study these matters tell us is that for hundreds of thousands of years, the human life span averaged around *35 years* … until around 125 years ago, when the average human lifespan started increasing. Recently, the average human lifespan has reached more than *70 years*.

To depict this improvement, I created the graph in Figure 1.1 from data made public by the World Health Organization.

In fact, in many parts of the world, the typical human lifespan is now more than *80 years*.

Obviously, living to 70 or 80 – rather than to 35 – is viewed by most people as a very good thing indeed! But what caused this doubling of human life expectancy? This question has been studied by the US National Academies.[1] Apparently, *engineering projects* deserve most of the credit, due to the following types of large-scale societal systems that have been created by such projects:

- Water treatment and delivery
- Sewage treatment and transport
- Motor-powered tractors
- Motorized transport and delivery
- Large-scale electricity generation and delivery
- Affordable, mass-scale refrigeration
- Canning and other mass-scale food storage/preservation techniques
- … and so forth.

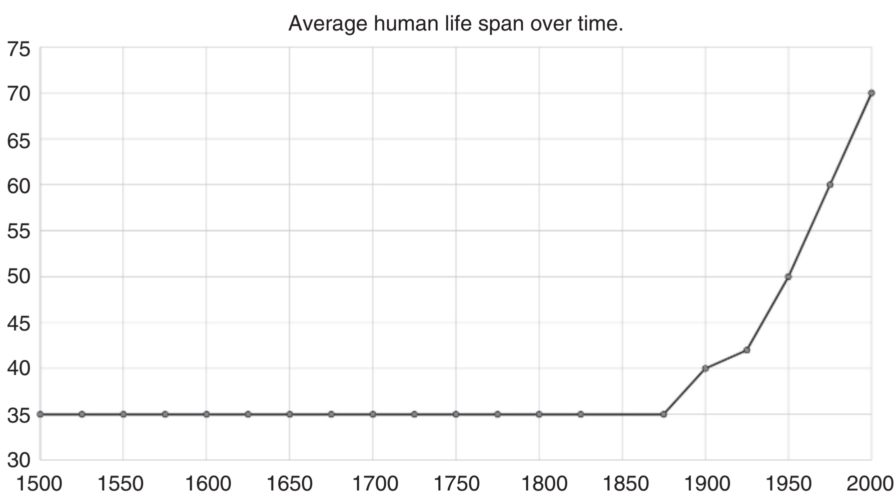

Figure 1.1 Human lifespan through the ages.

1 There are three US National Academies: Science, Engineering, and Medicine.

To be a little more precise, the National Academies estimate that 80% of the increase in human life expectancy is due to such engineered systems.[2] And *all* of these important societal systems were created by engineering projects!

Ergo: If you want to change the world for the better, become an *engineering project manager*! (We get paid pretty well too.)

My second assertion was that engineering projects are "of the essence" to business – they are the *only* source of revenue for many companies – and the creator of new methods and new products for almost every organization (business, government, non-profit organization, etc.).

Consider a company that builds airplanes and other similar aerospace systems. They obtain revenue by signing contracts with *external customers* (which might be their national government) who want to build something (e.g., a new military airplane, a government data processing system, an air traffic control radar, or whatever). The process of building this product is in fact an engineering project. It is the successful performance and completion of this engineering project that provides the company with its revenue.

Now, consider a consumer-oriented company like Apple, Toyota, or Microsoft. They don't have customers who give them contracts to build something; instead, they make their own decisions about what they want to build, use their own funds to build it, and then offer it for sale as a product or service in the market. But they would have nothing to sell if they did not undertake (in this case, at their own expense) an engineering project to create that product or service. The result of this *internallyfunded* engineering project might be a new version of a software product, or it might be a device (e.g., a new type of mobile phone, or a new model of automobile), or it might be a service (e.g., it might be software that allows them to do your accounting for you, using that new accounting software package). But whatever the result of this internallyfunded engineering project, it is the *project* that created the artifact that the company is able to offer for sale. Without the result of that engineering project, the company would have no revenue.

So, whether the "customer" who is paying for the conduct of the engineering project is *external* (as is usually the case for an aerospace contractor or a construction company), or is *internal* (as is usually the case for companies that build products for the general public), their revenue results from being able to offer for sale the results created by engineering projects. In most companies, in fact, this accounts for nearly 100% of their revenue. Hence, my assertion that engineering projects are "of the essence" to business.

My third assertion was that being the manager of an engineering project is a great job. It certainly was for me.

Why is it a great job?

- You have a lot of freedom
- You have a lot of responsibilities
- You have the ability to make a difference
- You have the ability to try out your ideas
- You have the ability to hone your people skills
- … and you are in charge!

We will talk much more about this aspect in Chapter 13.

Make no mistake, being the manager of an engineering project is usually difficult, and at times can be downright stressful. But undertaking something that is hard, yet at the same time worth doing (engineering projects are important for society!), and doing your best, usually

2 Most of the rest is apparently due to improved healthcare.

leads in the end to significant job satisfaction. I like to say that being the manager of an engineering project has two great attributes: It is both *interesting* and *important*:

- *Interesting*, because every project is different and difficult, presenting new problems to be solved.
- *Important*, because engineering projects, as described above, benefit both society and business.

1.1.2 The Opportunity For You

Becoming the manager of an engineering project might sound like something to which only a few people can aspire. That is not the case; in fact, there is *lots* of opportunity.

Think about it – many companies have lots of engineering projects, and every one of those engineering projects needs a project manager. And if the project is of any size, each engineering project needs many *subordinate managers* (e.g., people who are in charge of *segments* of the project) too. As we will learn in a later chapter, projects are usually organized as a *hierarchy*: someone is in charge of the entire project, but reporting to that person are people who each run a segment of the project, and so forth. So, in fact, engineering projects usually need lots of managers.

Being the manager of a large engineering project may sound a little scary. At times, it is. But there are lots of ways to prepare yourself for the role of being an engineering project manager (in addition to, of course, reading this book!). You might start by working on a big project … then become the manager of a small piece of that same big project … and then run a small project … and then run a medium-sized piece of a big project, and then run a mid-sized project … and thereby work your way up to running a big project. Each step along the way teaches you part of what you need to know, provides you with the necessary experiences, and allows you to improve your skills. Therefore, by the time you are offered some sort of management role on an engineering project, you will likely be ready for that level of responsibility.

1.2 The Project

At the beginning of the chapter, we defined a project as a deliberatelyundertaken endeavor to create something that we believe will be of value. Let's now go into this in a little more detail, so as to elicit a better understanding of the characteristics of projects, and why it is important to distinguish them from other activities (e.g., activities that are *not* projects).

Definition: A *project* is a *temporary* activity intended to create a product or a service.

By "temporary," we mean that a project has a deliberate commencement and termination; the project must proceed forward toward some *well-defined conclusion*, an *ending*.

Of course, every human activity eventually ends … but the point here is that a project has a ***planned*** end date. This contrasts with activities that are ***open-ended***, e.g., have no planned end date.

Here are some examples, to help you understand the concept that a project must have a *planned ending*, and contrasting that with activities that are open-ended:

- *Building* an oil refinery is a project, but *operating* the refinery after it is complete is *not a project*.
- *Inventing and designing* the next iPhone is a project, but *building and selling* them (until people stop buying that model) and then supporting them is *not*.

Projects	Continuous business operations
Temporary	Ongoing
Unique	Repetitive
Specific time-frame	***Open-ended*** time-frame
Situational	Standardized
Project-specific measures	Company-specific measures
Subtle performance indicators	Clear performance indicators
Focus is on creating something new	Focus is on reducing unjustified variation
Changes the status quo	***Is*** the Status Quo

Figure 1.2 Comparison of a project with a continuous business operation.

- *Building* a new web page is a project, but *using it* for sales and advertising once it is complete is *not*.
- *Making* a flower bouquet is a project, but *tending your garden year after year* is *not*.

Notice that the result of the project may be offered for sale, or may just be used internally by the creating organization. Both would qualify as projects; the result need not be intended for sale.

If the actions of operating the oil refinery, continuing to build and sell iPhones until people stop buying them, using the web page after it is complete, and tending your garden year after year are not projects, what are they? I term these *continuous business operations*, rather than *projects*. These types of activities are characterized by the fact that they proceed forward on an *open-ended* basis, without a well-defined conclusion or ending.

The table in Figure 1.2 captures these differences (and a few more that we will come back to in a later chapter) in a comparative format.

Why do we make this distinction? After all, the oil refinery will be shut down someday … which sounds kind of like a project! There are several reasons for making this distinction:

1. Projects have vastly more uncertainty than continuous business operations, and in projects, those uncertainties arise from different aspects than they do in continuous business operations:
   - In a continuous business operation, ***we are trying to operate the "status quo"***; our emphasis is on repeatability, reducing unjustified variation, controls, predictability, and slowly introducing modest improvements in our work processes. We are ***not*** emphasizing the creation of something new and revolutionary.
   - In contrast, on a project, we are precisely focused on ***the creation of something new***, and striving to create a revolutionary improvement in various measures of performance (capacity, capability, cost, level of unjustified variation, reliability, etc.). We are attempting to ***change*** the "status quo."
2. The flow of revenue in and out ("cash flow"; we will return to the concept of *cash flow* in more detail in Chapter 14) is completely different for a project than for a continuous business operation:
   - In a continuous business operation, we are ***expending*** money every day to operate the process and to produce our products. Our expenditures, however, ought to be fairly predictable: raw materials, labor, facility costs, and so forth; the nature of a continuous business operation is that past experience forms a pretty good guide to the level of new expenditures. We are also ***earning*** income every day, too: revenue from the sale of the products that we are producing. The financial goals for a continuous business operation are: (i) be reasonably predictable (ii) achieve the planned a balance between expenditures and revenue (that is, cover our expenditures from our revenues, with revenue actually exceeding expenditures by a specified amount, to provide for a reasonable profit).

- In contrast, on a project, we are expending money every day, but (i) we likely are ***not achieving any revenue from sales*** at all,[3] and (ii) (this is the main point) the range of uncertainty about our expenditures is far larger than for a continuous business operation. This is because projects are very complex, and it is normal for us to find new issues and problems as we progress, and these most likely require additional money to correct. We have set aside a small amount of money so as to be ready to deal with such contingencies,[4] but if we planned poorly, we may discover that the new financial needs are far larger than this contingency fund. Is it, unfortunately, not uncommon for a project to end up costing 5× and 10× what it was originally forecast; the financial uncertainty in a continuous business operation is almost always far, far less than this. A project inherently expends more cash than it generates during the entire time period of its development; the company must "loan" the difference to the project (we return to this aspect in Chapter 14).

3. A badly managed project can quickly turn into a financial and reputational disaster, and is much more likely to do so than a continuous business operation.

Because of these differences, the techniques, skills, and psychology of managing a project are usually quite different than that of managing a continuous business operation, and likely call for people with different experiences and expertise to act as their managers.

Let's focus on the cash-flow difference for a moment. Think about that oil refinery. Each month, it costs us money to operate it (we have to buy the crude oil, pay the people who work at the refinery, maintain the machinery, pay property taxes, and so forth), but we also receive revenue every day, as we sell the refined petroleum products that the refinery produces. Our monthly cash-out and monthly cash-in are continuous, and nearly equal (ideally, with cash-in being slightly more than cash-out, of course!) (see Figure 1.3).

This is completely different from the cash-out/cash-in profile (the finance people call this the "cash flow") of a *project* (see Figure 1.4).

As you can see, *projects spend money long before they return any benefits*. Because of this, managing the project to meet schedule and cost is *vital*. The most common ways to lose money – or otherwise run into difficulties – on a *project* are quite different from the most common ways to lose money (or run into difficulties) during a *continuous business operation*.

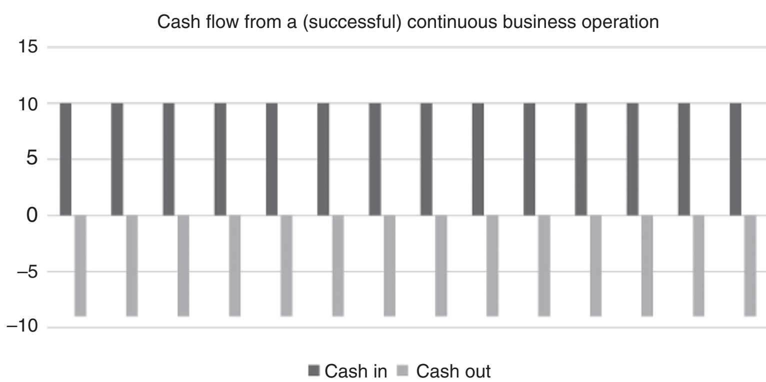

Figure 1.3 Cash-in and cash-out from a continuous business operation.

3 Our customer may be providing progress-payments for some – but most likely not all – of our current expenses.
4 We will call this contingency fund our **management reserve**, and it will be discussed in Chapter 11.

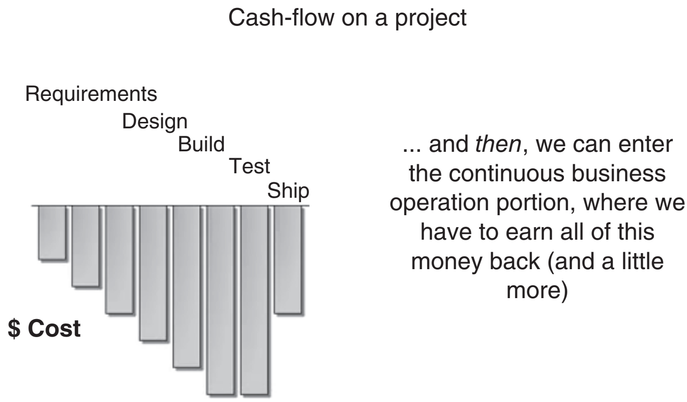

Figure 1.4 On a project, cash goes (mostly) **out**.

Furthermore, since through your project you are creating a product or service anew, the types of things that could go wrong (in a later chapter, we will call these "risks") are usually quite different from the things that can go wrong during a continuous business operation.

For all of these reasons, we therefore distinguish between a ***project*** and a ***continuous business operation***.

1.2.1 Where Do Projects Come From?

A project is created when an organization needs to *create* (or *replace*) a product or service. They therefore need a *temporary activity* to create that new (or revised) product or service. The project is *complete* when the new product or service has been created and is ready to start being operated.

Someone pays for it. This person or organization is usually called the "customer" or the "client." The actual customer may hire someone to oversee the project acquisition process for them; this person or organization is called the "buyer."

1.2.2 Customers

The customer can be *external* (e.g., outside the organization that is building the project; an example would be if the US Federal Government hired Lockheed Martin to design and build a new type of military airplane; another example would be your local city hiring a company to re-pave a particular road).

The customer can also be *internal* (e.g., Apple funding the design of the next iPhone). In this case, the customer is one set of people inside the company; the project will be performed by a different set of people inside the company.

In fact, there are usually *multiple* customers for a project: those who are *paying*, those who are *buying*, and those who will be *using* the resultant product or service. We will discuss this aspect more in Chapter 4.

1.2.3 Attributes of Projects

Projects are *important*.

- Therefore, we aim to be *rigorous*. We achieve this rigor via appropriate levels of planning, via the use of credible analytical methods, and via formal procedures to verify the correctness of our project's products and services

Projects are *difficult*.

- Therefore, we aim to *learn from past experiences*, and from *experts*. We accomplish this learning via *engineering and management processes*. A *process* is written guidance about how to accomplish a task. The process is written in a fashion to incorporate the lessons our organization has learned from performing on previous projects: both those projects that were successful, and those projects that were not. We use such processes to guide engineering activities, management activities, personnel activities (e.g., recruiting and hiring), and many other things that we must do in order to complete our project.

Projects involve *more than one person*.

- Therefore, communication among the team members is "of the essence." We accomplish this via *written artifacts, face-to-face meetings, and many other methods* so as to ensure that "we are all on the same page."

1.2.4 The Project Life-Cycle

It has been found useful to group the steps typically undertaken to start, perform, and complete a project into a standardized set of categories; these categories (I will call them *stages*), taken together, form a conceptual *life-cycle* for a project. Figure 1.5 shows one version of such a depiction of the project life-cycle.

Actually, "Produce it" and "Use it" are likely to be "continuous business operations," as I defined that term above, rather than a "project," because they usually will not have a well-defined completion date. But almost everyone includes them in such depictions of an engineering project life-cycle; I will do that too.

In Chapter 2, I introduce my own particular version of the project life-cycle, which we will use for the remainder of the book.

You will see that as we discuss various steps and methods of engineering project management, they generally can be related to one or more of these six life-cycle categories.

1.2.5 Goals of the Project/Factors in Tension with Each Other

An engineering project will usually have more than one goal. For example:

- We want to complete the project, having built a product or service that has all the required capabilities.
- We want to complete the project on the end date that we promised.
- We want to complete the project within the amount of money we promised.

The goals usually tend to compete with, or *be in tension with*, each other. For example, one could usually increase the probability of completing the project on time (and within the allocated budget) if one omits some of the required capabilities.

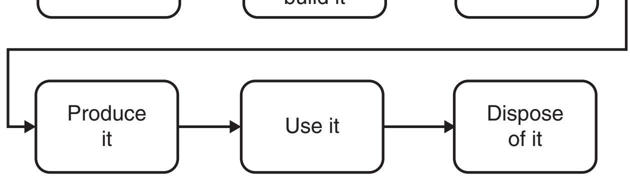

Figure 1.5 An example of a project life-cycle. *Source:* Adapted from http://www.almc.army/mil/hsv/2001-DL.PDF.

The essence of engineering project management, therefore, is achieving a *balance* between these competing goals. One may have to work very hard, for example, to create a design that provides the required capabilities while also staying within the constraints of time and money. It is often the case, in my experience, that it is relatively easy to find a design that seems to work, but much harder to find a design that works while also staying within the constraints of time and money. As the manager of your engineering project, you must find a design that *accomplishes a large portion of* ***all*** *the goals*. This is an example of resolving factors that are in tension (in this case, capability, schedule, and cost, but there are others, too, which we will discuss in due course) by achieving a *balance*. Maybe you decide that there are a few capabilities that are not actually needed, or not worth the cost of implementing them; you can go back and show your customer how much time and money you could save by omitting them, and obtain their written concurrence to do so. This is a very typical action for the manager of an engineering project.

You may also have to reject a design that would in fact work, but one that you determine would take too much time and cost too much; you must create a different design that will achieve a better balance. This, too, is a very typical action for the manager of an engineering project.

But you must do all of this without taking inordinate risks. For example, someone on your team may promise you that they can develop a revolutionary new algorithm that will perform the necessary computations 10 times faster than current algorithms, and such an improvement is needed to meet all of your requirements. But this revolutionary new algorithm is still just a promise, and many things can go wrong between the promise and completion of a useable algorithm. Later in the book, we will call something can might possibly go wrong a *risk*, and show you how to achieve balance between promises and failure for such risks.

Therefore, I (along with some others) place a fourth item on the list of key goals for your engineering project:

- Managing the risks that will be encountered by the project, so as to avoid catastrophic failure.

In addition to the risk that the project will not work, there are other categories of risk: for example, that in the conduct of the project, we might inadvertently harm people or the environment.

Risk is one key area where engineering projects are different from other sorts of projects (art projects, construction projects, etc.); since we are often inventing new things via our engineering projects, we often face far more risks – and more profound risks – than do other types of projects. Engineering project managers must *always* think about risks.

Because of the centrality of risk to engineering projects, I always like to focus on these four constraints as the key factors in tension that I must manage over the course of my engineering project. I call this the *quadruple constraint* (Figure 1.6). Not surprisingly, those who only use the first three items on the list call their version of this list the "triple constraint." That shorter list may be fine for other types of projects, but for engineering projects, we will usually need my version, the quadruple constraint.

- We must complete the project having built a product or service that has all of the required capabilities
- We must complete the project on the end-date that we promised
- We must complete the project within the amount of money we promised
- We must manage the risks that will be encountered by the project, so as to avoid catastrophic failure

Figure 1.6 The quadruple constraint.

If your project is for an external customer, the elements of the quadruple constraint are usually expressed in a legally binding document called a *contract*. One portion of this contract (called *specifications*) will define the *capabilities* ("what" your project's product or service is supposed to do) and *quantifiable measures* ("how fast, how far, how long, how reliable"). The contract will also specify a *date* by which the product or service must be delivered and the agreed-upon *price* that you will be paid when the work is complete to the satisfaction of the contractual terms.

Often, there are financial incentives and penalties; perhaps you don't get paid until you prove that the project satisfies all of these requirements; or there are penalties for being late; or there are bonuses for completing the product on time; or some combination of all these.

On complex projects, it is common for the contract also to mandate certain standards for *how* the work is accomplished, in addition to the specifications for the end product. For example, the contract may require certain engineering and/or business methods to be employed; these are one of the ways in which the customers show that they expect *you* to manage the risks that will be encountered by the project.

If your project is for an internal customer, the written documents that embody the quadruple constraint will still exist; they may be less formal, and probably are not legally binding. But your management still expects you to adhere to them! Your promotions, and perhaps even your job, will be on the line.

So, what constitutes success for an engineering project?

- Meet the quadruple constraint:
  - Within allocated time
  - Within budgeted cost
  - At proper capability and performance level
  - And with risks kept under control.

But also:

- Accepted and liked by the buying customer
- Accepted and liked by the users
- Without disturbing the main workflow of your company
- Without exhausting, hurting, or demoralizing your people
- And accomplish all of the above while complying with all applicable laws, regulations, and company policies.

The quadruple constraint defines a major portion of *all* engineering projects, whether external or internal. The specifics of your engineering project determine the relative importance of each dimension of the quadruple constraint. Sometimes, capability is the most important. Often, meeting the promised delivery time is the most important. Every customer cares about cost and risk too.

How do you know the right balance of emphasis for your project? Through frequent and forthright discussions with your customers (remember, however, there are usually *multiple* customers for your project, and they likely will not agree with each other on all matters), your technical personnel, your corporate management, and other stakeholders and experts. You must do this not just at the beginning of the project, but on a continuous basis.

1.3 The Project Manager

1.3.1 The Role

Whether the customer is internal or external, the project is performed by some set of people; this set of people is called the "project team" or the "development team." That project development team is led by someone; that person is the *project manager*.

Sometimes the same term is also used for the person in charge of the *buying organization*; but in this book, we will reserve the term "project manager" to signify the person in charge of the *project development team*: the team actually building the new product or service.

Being a project manager is about "doing," not "consulting." You are responsible for achieving a good outcome, creating the capability of the delivered product or service, completing the project on time, completing the project for the amount of money agreed to, and many other things. You are provided with the authority necessary to accomplish those ends.

You lead a large number of activities: planning the activities; recruiting, motivating, and aligning the people involved; managing, monitoring, and controlling the project's activities; ensuring that the work is actually accomplished according to the plan and according to the requirements in your contract (more about that later); verification of completeness and quality; and many other things too.

Projects are almost always accomplished by *teams*, not by single individuals. The image in the movies of one person sitting at home and building something over the weekend that changes the world seldom happens. It almost always takes *teams* – in fact, often large teams – to accomplish something important.

As the project manager, therefore, you will break the project into small pieces, and then assign responsibility for each piece to a named person.

Since the work is being performed by a team, you must ensure that all of the people on that team have:

- A shared vision of the desired outcome of the project
- A shared understanding of the means and methods that will be employed to create the desired outcomes
- A shared knowledge of the constraints (including schedule and cost).

This is the *alignment* that we will depict in Figure 1.8 below, and discuss in more detail in Chapter 13.

Furthermore, each member of the team must learn to derive *his or her* satisfaction (at least, in part) from the accomplishments of the *team*, rather than solely from *their own* accomplishments. You must create the conditions whereby this can take place. Note that this is quite different from what we are taught to do in school; in school, although we may occasionally participate in a team project, the general emphasis is that we do *our own* work, and derive our satisfaction and sense of accomplishment almost exclusively from our own work. This is *not* at all how real engineering projects work; what matters on an engineering project is the accomplishment of the *team*.

A good team can do so much more than any single person! Fashioning the team in such a manner that it can actually realize this potential is part of your responsibility as project manager.

As the manager of an engineering project, you have both *authority* and *responsibility*.

- *Authority* means that you have been designated by your company or organization as being the person allowed to make certain types of decisions regarding the project. The types of decisions that you are authorized to make are usually spelled out in writing, and likely include decisions about selecting personnel for your project (usually you also get a role in determining their compensation), technical decisions about the design, what companies and vendors to use to provide parts and services, and so forth. And, of course, you also have authority to select the design, the tools, and many of the methods.[5]

5 Sometimes, your company or your contract will specify some of the methods.

- *Responsibility* means that you have accepted that you have the obligation to accomplish all the goals of the project within the constraints and limits that have been specified to you. These constraints and limits are also spelled out in writing, and likely include items such as how much time it will take to complete the project, how much money the project will cost, what you will deliver, that you will not do anything illegal or against your organization's rules and policies (or knowingly allow someone else on the project to do anything illegal or against your organization's rules and policies), and so forth.

Since the project you will be leading is an *engineering* project, and we are engineers, it is natural to think that most of our time, and most of our decisions, are about engineering. This is *not* correct; as the manager of an engineering project, we have many responsibilities other than engineering. In fact, we lead *every* aspect of the project, which includes social factors and matters of business, contracts, and finance (just to name a few), in addition to technical and engineering matters. Being the manager of an engineering project is a very multi-faceted role. We need to learn a little bit about a lot of subjects. We do not need to be an expert in all of them, but we need to know enough to be able to talk effectively to the experts in each discipline.

My own opinion, however, is that it is vitally important that the manager of a complex engineering project be an engineer. You will not be the lead designer; you will have someone working for you who fills that role. But in many of your interactions, you must judge the credibility of the people to whom you are talking, and on an engineering project the majority of those people are fellow engineers. And engineering considerations are central, as we said at the beginning of the chapter, to the success of the project (otherwise we would not consider it an *engineering* project).

But, even though you are an engineer, you lead and integrate *all* of the aspects of the project, not just the engineering. As we will see in a later chapter, there are many different aspects to a project and many different specialists with whom we must interact.

You also lead the interaction with all of the people involved in the project. This includes your team, the people who will actually do the work of the project. But you will interact with many more people than just your team; we use the term *stakeholders* to indicate all of the various people who have some sort of vital interest in the outcome and conduct of your project. Examples of such stakeholders include:

- Your management
- Corporate specialist staff functions (e.g., human resources, finance, law, contracts, and quality)
- The people and organization who are paying for your project
- The people and organization who are buying your project (these are usually hired by the organization that is paying for the project)
- Your users – the people who actually will be *using* or *operating* the product or service, once you complete it
- Other interested and affected parties, sometimes including the general public.

Let's examine some of this nomenclature; in particular, let's discuss the distinction between *paying* for the system, *buying* the system, and *using* the system.

Here is an example. In the US Federal Government, it is Congress that pays for a project (the US Constitution says that *only* Congress has the power to authorize the spending of public funds), but Congress always designates some executive agency to act as the *buyer*. For example, Congress might decide to acquire a new type of military aircraft, authorize the spending of a certain amount of money to pay for an engineering project to design and build this new aircraft, and might also designate the US Air Force as the agency to act as the buyer for this project. By the term *buyer*, we mean someone acting on behalf of those who are paying for the project to select someone to build it for them and to oversee the builder's progress. Congress has neither the time nor the skills to select a company to design and build this aircraft, so they designate someone from an organization with the appropriate expertise to do it on their behalf. In fact, there will be a specific person within the Air Force named as the buyer for your project. That buyer will have an entire team of their own, too. But neither Congress nor that team of people who act as the buyer are the people who are going to fly that new military aircraft when it is made; the actual *users* of the product of our engineering project will be Air Force pilots, and the senior officers within the Air Force who command them. So, we have funders, buyers, and users who in this example are all distinct from each other. In some simpler projects, the buyer might be the user, but most of the time, these are three distinct roles. Really, *at least* three distinct roles: there may be multiple users … and they may not always agree with each other!

Of course, there might be many other people who are interested and concerned about your project. Our new military aircraft probably has to fly over areas where there are US Army and US Marine Corps personnel, so those branches of the US military will also have ideas about how our airplane should be designed. Our airplane will be based at air bases within the United States (at least, during peacetime), and will make noise, cause pollution, and so forth, even during routine training missions over the United States, so local city and state governments, environmental groups, and even the general public are to some extent stakeholders too.

And since in our example it is the US Congress that is funding the project, we ought to point out that many different people and organizations have opinions about the purposes for which Congress ought to authorize the spending of public money; in some real sense, all of those people and organizations are potential stakeholders and influencers on your project.

As the manager of your engineering project, you have to interact with *all* of these people. You synchronize and align all of them. You work with them so that they understand and agree with your goals and limitations. You help them understand your approach to the project (e.g., in what order and sequence we will do the various steps, and so forth), and to some extent, you must even help them understand your design (so that they can agree that the design is credible). You must keep them working in alignment, keep them motivated, and keep them believing in the value of your project. You must collaborate with them to keep the project sold; we will learn later in the book that most engineering projects that are started are in fact *not* completed successfully; most encounter problems, and many are stopped before completion. It is part of your job to deal with the problems as they arise (and ideally, to anticipate them in advance!), and do so in a fashion that allows all of the stakeholders to agree that the project should be allowed to continue until it is complete.

Let me say a few words about "synchronizing and aligning" people. We have all had experiences of a situation where it seemed like everyone in the room had a different opinion about how something ought to get done, even something simple like what toppings we want on tonight's pizza. In a complex engineering project, we must resolve these differences of opinion and reach consensus. This process of reaching consensus is not just a matter of getting people to agree with you; instead, it is a chance for many people to contribute ideas and create a plan that is better. One cannot make progress on a complicated endeavor like an engineering project unless one reaches such a consensus. There are literally hundreds, if not thousands, of such matters to be addressed. What programming language will we use? Will we use a licensed or unlicensed radio frequency spectrum for communications? How long does the battery have to last between recharging cycles? Some are design issues. Some are what we will call *process* issues (e.g., what are the methodologies and tools – that is, the process – that we will use to accomplish our goals). Some are personnel issues; for example, two team leaders might both

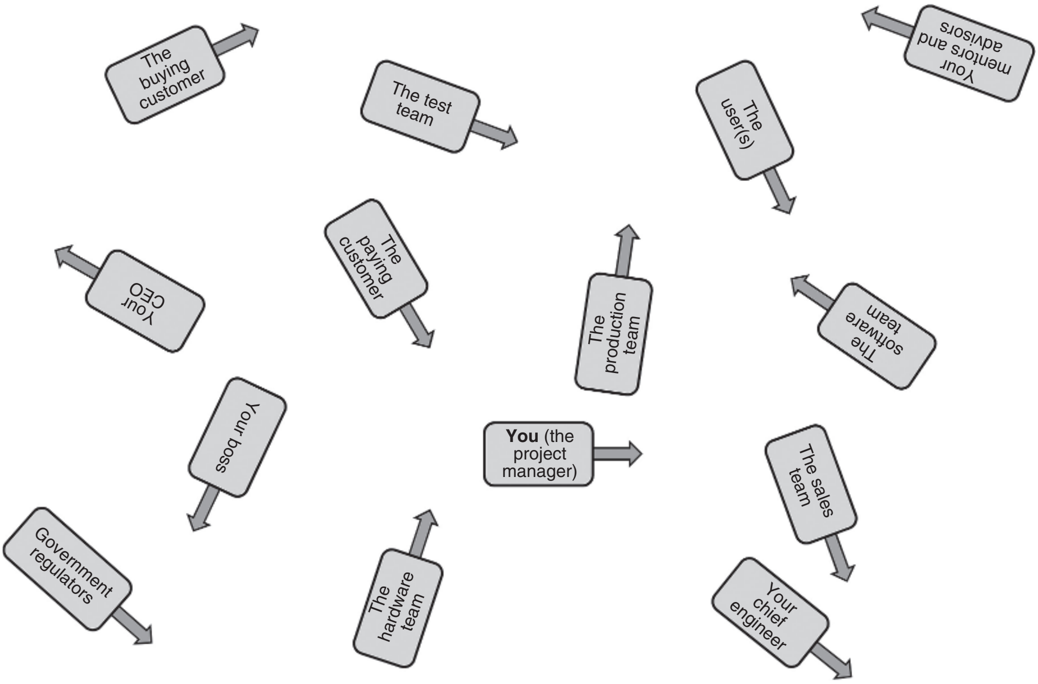

Figure 1.7 An unaligned team.

want to hire the same engineer. Some are legal issues; for example, does our contract allow us to buy the jeweled bearings that we need from a vendor outside of the United States, or not?

We need to *align* our team. What do I mean by that expression? Here's an example. I like cats, but when we had four cats all at once it was often chaos at home; they each had their own ideas about priorities, objectives, methods, and who ought to be in charge! In that case, it was cute and often a little silly. But you cannot be an effective manager of an engineering project without herding those cats! When we start, everyone will have a different opinion, on each of hundreds of matters. Our team looks like Figure 1.7. That is, all heading in different "directions"; each has its own ideas about priorities, objectives, sequence, tools, methods, design concepts, and so forth.

What we need to do is to get the team to look like Figure 1.8 instead. That is, we need to reach a state where we have a shared set of goals; a shared plan for methods, tools, and techniques; an agreed-upon sequence of steps; shared priorities; agreed-upon concepts for the design; and so forth. We do not reach this state all at once; indeed, even if you have a great plan with which to start, every single day you will discover new areas and additional details requiring new discussions, new realignment, and additional decisions. That is part of what makes the job so interesting!

1.3.2 You as the Manager of an Engineering Project

According to the dictionary,[6] *management* is (i) [verb] the judicious use of means to accomplish an end (ii) [noun] the group of those who manage or direct an enterprise. So, by *management*, we can mean either the process and activity of overseeing an activity to accomplish an end goal,

6 Merriam-Webster, © 2000 Zane Publishing, Inc.

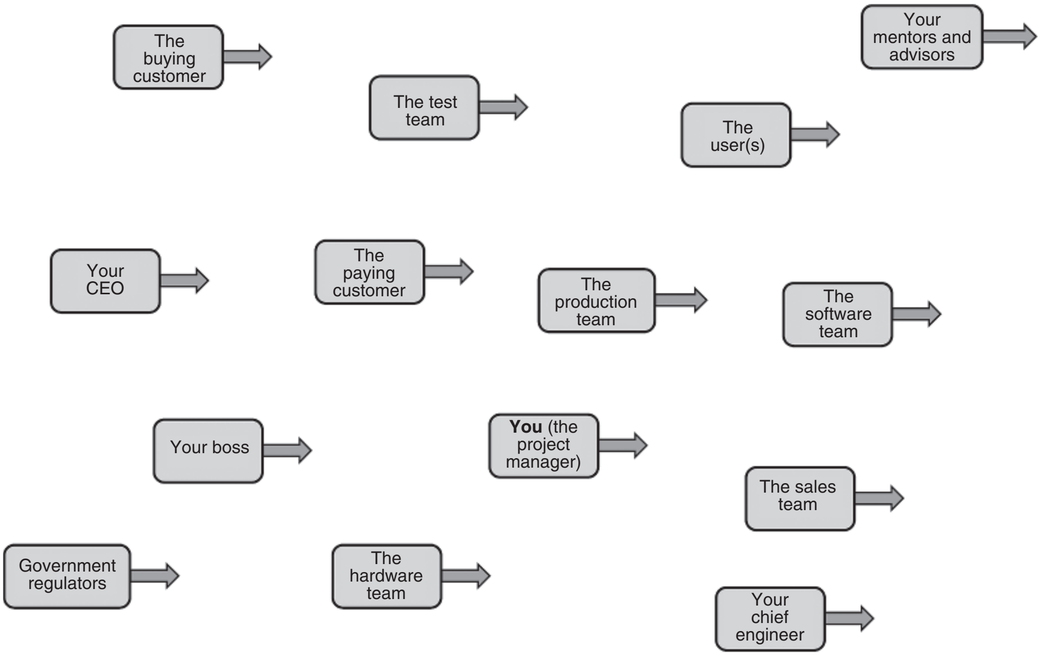

Figure 1.8 An aligned team.

or the person or people that perform such an activity. In this book, we will talk about both the process of management and the person who is the manager.

Our project is an engineering project, and we said that we call it that because engineering and technological considerations are central to the success of the project. But only a portion of the people working on your project are engineers performing engineering tasks; there are many other people with other skills as well. You manage *all* of them, not just the engineers. Let's look at your responsibilities.

- You work with your customer(s) to establish the *goals* of the project (e.g., what we are trying to build) and the *constraints* within which you and the team must accomplish them (time, money, laws, company rules, and so forth).
- You lead the *planning* of the project, by which we mean determining in advance what you will do, in what sequence, who will do each portion, how many people with what skills will be required, how we will obtain access to those people, where the work will be performed, what methods and tools will be employed, what records will be kept, and many other matters. These must mostly be determined in *advance* of the commencement of the project and must be committed to writing.
- You lead the effort to agree upon methods for *measuring progress* of the project, in every applicable dimension: technical, schedule, staffing, cost, risk, and many others.
- You select the *key people* for the project, and negotiate so as to reach agreement with each of them regarding their role (responsibility and authority), committing these agreements to writing.
- You *motivate* those people to work effectively, to work well as a team, to believe in the importance of the project and its objectives. As we will discuss later on, it turns out that motivated people are far more productive than unmotivated people, which is important in achieving success in your project.

- You *monitor* the progress of your project as it proceeds, by which we mean you periodically compare results to date against your plans, and if there are material differences between those results to date and the plans, you take actions to resolve those differences.
- When the project reaches its conclusion, you take actions to *close-out* the project, which includes finding new work assignments for all of your personnel, returning facilities to the control of the company for other uses, archiving documented materials, properly dispositioning materials, closing the accounting books, and so forth.

In summary, you as the manager of an engineering project will direct the application of knowledge, skills, tools, and techniques to a set of activities that are designed to meet the needs and goals of your project. To achieve success (and to do so safely, legally, and ethically) is your *responsibility*. In order to execute those responsibilities, your company or organization will grant you certain *authorities*, that is, you can make certain types of decisions, commit certain types of resources, and so forth. But you do *not* have to invent all of this by yourself, or from scratch either.

1.4 Engineering Processes Can Help You

Other people have been managers of engineering projects before you, so you can learn from their experiences (both the positive and negative parts of those experiences!). Most organizations that undertake to perform engineering projects have captured the lessons learned from previous projects, in the form of written guidance about *how to do each of the different types of activities involved in an engineering project*, ranging from planning to execution, monitoring, dealing with personnel, and close-out.

We call this type of written guidance about how to conduct the steps of an engineering project an *engineering process*. Each engineering process might take the form, for example, of written step-by-step instructions, or the form of checklists, or be in other formats. But they are *always* in writing and are always intended to tell you and your team how your organization expects your project to perform each type of project activity, to show you what artifacts that activity needs to produce, and what is expected on the content and format of those artifacts.

In addition to a library of such engineering processes that your company or organization might have, there are a variety of other organizations that create and publish guidance for how to conduct an engineering project. Examples include the Project Management Institute,[7] the Institute of Electrical and Electronics Engineers (usually known by its initials, IEEE),[8] and the US Department of Defense. In fact, your company's engineering process library most likely draws upon information from some of these sources.

So, there is a rich body of guidance available to you. Furthermore, there are actual examples of previous artifacts; most large companies build libraries of these too, for the use of new projects. In such a library, you can see an actual project plan, an actual risk register, an actual software test plan, and so forth. You can even use these as a model for your own project, adapting these existing artifacts to the specifics of your project.

Good companies also require that their engineering projects, after they are completed (whether successfully or not), contribute data to the library of past project artifacts and data and also a written "lessons-learned" report; these reports should also be made available to new projects. This is a chance for your peers to learn about what worked and did not work on your project.

---

7 https://www.pmi.org.
8 https://www.ieee.org/index.html.

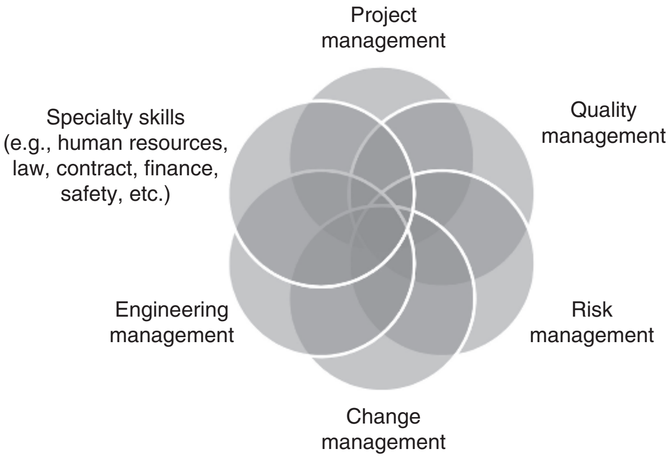

Figure 1.9 Engineering project managers must be able to interact with many different specialists.

In this book, we will frame many of the discussions in terms of "this is what the typical engineering process guidance says about how to perform this step," but we will also include a lot of discussion based on my own personal lessons learned from having been the manager of several large, complex, and successful engineering projects. What I have found is not that the books and the engineering processes are wrong, but that they are often woefully incomplete, and don't tell you what is actually vital to your success. In fact, that lack is exactly why I have decided to write this book!

As we noted above, although engineering is central to the success of your project, many of the people who do make important contributions to your project's success are not engineers. I have depicted a representative sampling of the range of people and skills with whom you will have to work in Figure 1.9.

As the project manager, you must manage and work with all of these people. Because of this, you have to learn a bit about each of those specialty skills – contracts, law, human relations, configuration control, quality management, and many others – so that you can interact with those people, reviews their plans and progress, and provide guidance to them, just like you do for the engineering staff. But you do not need *yourself* to become an expert in everyone of these disciplines; no one could actually accomplish that! The way I like to think about it is that you need to know how to *talk to* each of these experts, but need not *be* an expert in each of these fields yourself.

We will therefore talk quite a bit about these non-engineering domains in this book. Your company probably has short courses that you can take in some of these fields and certainly has manuals that describe the roles, processes, artifacts, and controls for each. My experience is that it is well within the capacity of an engineering project manager to learn all that he or she needs to know in order to work effectively with these specialists. Of course, you must devote time and effort to that learning. We will do some, but by no means all, of that learning over the course of this book.

1.5 The Engineering Project Manager Mind-Set

I have found that a certain mental orientation helps make for a better engineering project manager. You must:

- Be willing to spend time and effort to create realistic planning documents, in each of a number of domains (which we will name in a future chapter).
- Be committed to the success of the project, and be able to motivate your employees to share that commitment.

- Be able to persuade people with the requisite skills, a good work ethic, and who are willing be work effectively within a team,[9] to come and work on your project.
- Be willing to spend time learning about your customer, what they value, and what they consider success (this is among the items on this list that I consider the most important; we return to this topic in Chapter 4).
- Be willing to spend time to build relationships of trust with many different people – your customers, your management, your other stakeholders, your employees, and your suppliers.
- Collaborate with your team to create a clear statement of scope and objectives for your project, and be willing to spend the time and effort necessary to obtain alignment of your team and stakeholders so that they agree with those descriptions.
- Motivate your team so that they believe in the importance of the project, and in the feasibility of the plan for implementing it. Motivated people do more work!
- Be willing to accept that things will go wrong; spend time to create effective risk management and quality systems so that you can spot them and correct them.
- Be willing to solicit and to act on the advice of a few other people (whose knowledge, experience, ethics, and leadership style you respect); you cannot do this complex and demanding job without help.
- Be willing to insist on (and invest in) appropriate tools, technologies, methodologies, and techniques.
- Always be thinking ahead, looking for what might go wrong, and looking for opportunities.

This is a hard list, but I have found that most good engineers can learn to do it. All of these items are discussed somewhere in this book.

An engineering project, however, is *not* a science project; it is important to understand the difference between science and engineering. Look at Figure 1.10. *Science* seeks to make reliable and verifiable quantitative predictions about the behavior of the physical world; it accomplishes this by investigating underlying mechanisms and principles. *Engineering,* in contrast, seeks to do something quite different: it is concerned with creating a practical application, or a

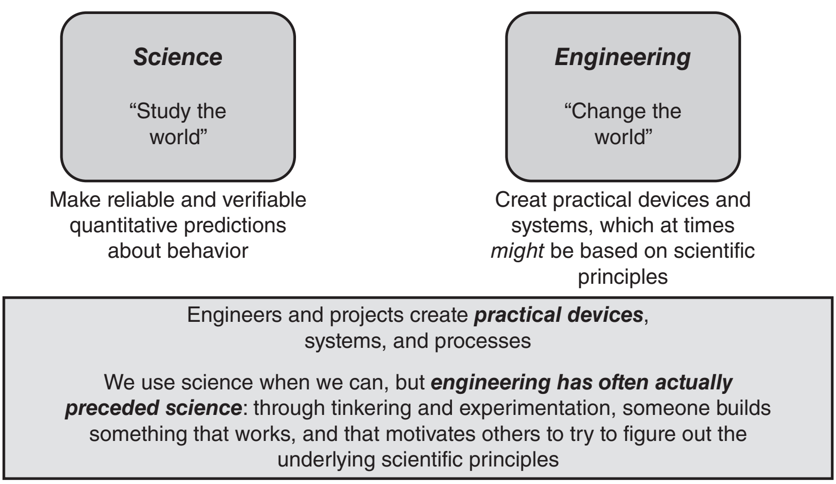

Figure 1.10 Science and engineering have different objectives.

9 We will talk much more about these factors in Chapter 13.

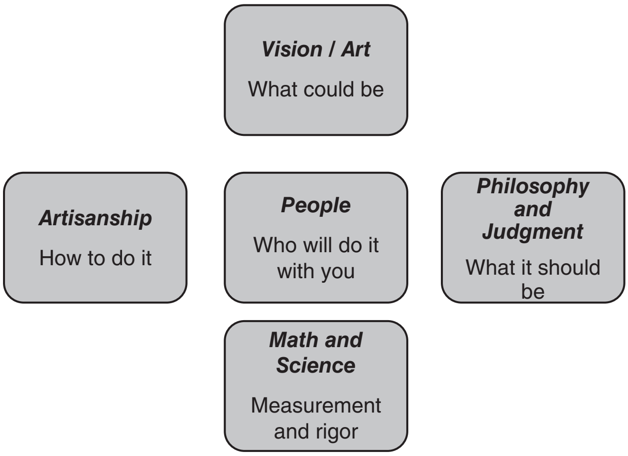

Figure 1.11 "The tao of engineering project management."

practical effect. Engineering is *not* knowledge for the sake of knowledge; such knowledge is important, but it is a job for scientists, not for engineers and engineering projects. We, in order to be effective engineering project managers, must keep our focus on achieving those *practical results*. But our projects must be feasible too; therefore, we may well have to consult with scientists in order to make sure that we are not promising more than we can feasibly deliver.

A presentation by an Englishman named Chris Wise (who, at the time, was a professor at University College, London) that I attended in 2013 got me thinking about what one might call "the tao of engineering project management"; *tao* is a Chinese word meaning approximately "way" or "path." I believe that the path to successful engineering project management encompasses much more than engineering. I have adapted what Professor Wise said to arrive at Figure 1.11.

As engineers we must base our work on facts, measurement, and rigor; it must actually achieve a practical result in the real world. But that is not enough; we must exercise judgment about what our product *should* be, create a compelling vision of what it *could* be, and use craftsmanship and artisanship to *build it well*.

Lastly, we must meet the ever-rising expectations of our users and the general public. If you are a baseball player, you have the luxury of being considered a great success if you get a hit 30% of the time; that means you are allowed to "fail" 70% of the time! Not so in the world of engineered products; those are expected to work essentially 100% of the time. That may not seem fair, but it is a fact. We must also achieve the desired benefits of our product, but minimize the *unintended adverse consequences* (we will say a *lot* more about this in later chapters). Actually, our track record as engineers is pretty good (think of that doubling of human life expectancy that we talked about at the beginning of the chapter), but expectations are *very* high, and continuously getting higher. What was good enough yesterday will not be good enough tomorrow.

1.6 Next

Having set the stage, we are now ready to spend two chapters (Chapters 2 and 3) discussing how we actually do engineering on projects. We will then use that knowledge to optimize our project management procedures in light of those engineering processes.

1.7 About Facilitated Lab Sessions and Practical Exercises

Engineering is all about achieving practical results, and in that spirit of "hands-on" practical results, my class does *not* consist entirely of lectures. I use nearly half of the class sessions for what I call *facilitated lab sessions*. During these facilitated lab sessions, I take a short amount of time to explain a technique, and then provide the students with a problem which they work on (in teams) during the class session. They are allowed to consult with each other, to look at their class notes and books, to ask me questions, to show me their in-progress work, and get feedback on the spot. What I find is that they seldom actually finish the work during this class session (and therefore, they still have to do that work as homework), but by the end of each facilitated lab session, they understand the method properly and are able to solve the problem correctly.

Therefore, my course on engineering project management – and this book – are laid out as two parallel, week-by-week tracks: one of a progressive set of lectures and one of a progressive set of practical techniques and team exercises. As the students' knowledge and practical techniques are built up and mastered, this leads to a set of gradable course materials and an integrated set of learnings (via a combination of their reading, the lectures, the hands-on facilitated sessions, individual homework assignments, and team homework assignments) for each student.

At the end of the chapters that correspond to the weeks that have these facilitated lab sessions, there will be a section that addresses the topic, technique, and assignment for that week's session. What follows is the first of those sections.

1.8 This Week's Facilitated Lab Session

This week, we will explore the motivation for engineering projects and their contribution to the world. We will start by expanding on the contribution described at the beginning of Chapter 1: engineered systems that doubled the human life-span as the most important human accomplishment of the last 2,000 years. We will then branch out a bit and look at some other contributions of engineering projects to the world.

1.8.1 Exemplars

Consider the following six exemplary engineers.

1. *Thomas Edison*. The inventor of a practical electric light bulb (i.e., one that would last more than a few minutes, put out a reasonable amount of light, was reasonably rugged, not outrageously expensive, and could be manufactured in large volume), so that humans could have safe and effective light at night. Note that in some real sense, Edison did not solve this problem via improved science, but much more by "tinkering"; he tried more than 1,000 combinations of materials and preparations before he found one that he considered practical. He was obsessed with achieving a practical effect.
2. *George Westinghouse*. The inventor of alternating current, so that electricity could go a long distance. Edison's plan was to use the conceptually-simpler direct current, but direct current fades very quickly over distance as it travels through wires. We would have needed an electric power generating station on every block if we used direct current! Westinghouse had not only to solve the engineering problems so as to create a practical alternating current power distribution system but also to overcome the fame and credibility that Edison had already established, in order to get people even to consider his approach based on alternating current. That is, there were significant social barriers to getting people to use his approach, not just technical barriers.

3. *Nathaniel Wales*. The inventor of the first practical electric refrigerator, which has contributed significantly to humanity through its ability to preserve food against spoilage for long periods of time. Of course, if Westinghouse had not first invented a practical electric distribution system (based on alternating current), Wales could not have invented his refrigerator.
4. *Norman Borlaug*. Often called the creator of the "green revolution" in farming. Through the use of practical plant breeding, soil science, and engineering techniques to model growing patterns for crops in areas other than their native locations, he led the world to a massive increase in food production.
5. *Simon Ramo*. By 1949, both the United States and the Union of Soviet Socialist Republics (USSR[10]) had nuclear weapons. Europe had a 1,000-year legacy of major wars almost every 10 years (there was a gap of only 21 years from the end of World War I to the beginning of World War II, and this gap was itself filled with many smaller wars). The leadership of neither the United States nor the USSR wanted a nuclear war, but what was needed was a way to use the potential power of nuclear weapons to *deter* other countries from attacking. Missiles that could fly quickly and reliably from one country to another carrying a nuclear warhead were recognized as a way to create such deterrence; since (at that time) they could not be stopped, neither nation could attack the other without risking that the other nation would shoot its own nuclear missiles at it. The United States had a design for such a missile but was failing in its attempts to build a practical missile out of that design. Since those in charge were certain that the missile would be of fairly poor accuracy – only guaranteed to fly within a few miles of its selected target – they concluded that giant, very powerful warheads (which would be very heavy) would be required. But carrying these heavy warheads required gigantic missiles, and those gigantic missiles turned out to be relatively fragile and unreliable. An unreliable missile does not create deterrence! In desperation, in the mid-1950s, the US Government turned to a pair of brilliant young engineers named Simon Ramo (see Figure 1.12) and Dean Wooldridge, and asked them to solve the problem. They decided

Figure 1.12 The author with Dr. Ramo, 2011. On the occasion of the author receiving the Simon Ramo Medal for systems engineering. *Source:* Photo by Northrop Grumman. Used with permission.

10 The largest portion of the USSR became the Russian Federation in 1991, upon the dissolution of the Union of Soviet Socialist Republics. The Russian Federation inherited most of the former USSR's nuclear weapons and missile systems.

Figure 1.13 Judith Love Cohen in 1959. *Source:* Photo by Space Technology Laboratories. Used with permission.

that the design was wrong; we had to make a more accurate missile, which would enable the use of a less powerful and lighter-weight warhead; the lighter weight of the warhead would enable the use of a smaller missile, and this smaller missile could be made very reliable. The result was a credible deterrent, and that – so far! – the United States and the USSR have *never* gone to war against each other, even with conventional weapons. Most analysts credit this long period of peaceful coexistence (in part) to the deterrence achieved by Dr. Ramo's and Dr. Wooldridge's small, reliable intercontinental missiles.

6. *Judith Love Cohen*. As noted above, one of the key problems in creating a viable nuclear deterrent was improving the accuracy of the missile guidance system, so that a nuclear warhead that was far smaller (and therefore, far lighter in weight) could be used; this would allow the missile needed to carry that warhead to be far smaller. My mother, Judith Love Cohen, was one of the members of the team of engineers who designed and built the first all-electronic missile guidance computer, which was an essential ingredient (along with a highly accurate gyroscope, and other components) in achieving the necessary accuracy and reliability (Figure 1.13). She started this work in 1952 and continued working on it (and other electronic guidance systems, including the one for the Apollo moon missions) into the 1960s. As noted above, they succeeded in creating a revolutionary new missile guidance computer, one that was small enough to fit in a missile and rugged enough to withstand the vibration of a missile in flight.

1.8.2 Points for Discussion

In each case cited above, the engineer cited created a *better design* than the preceding one. They looked at a wider range of options, including options that were not even considered previously. Your assignment today: identify and discuss the design selected, and how it differed from previous design attempts.

Their inventions had unintended consequences too. This is a vital observation, to which we will return in later chapters. The next portion of your assignment is to identify examples of such unintended consequences and discuss the implications. For example, increasing the human lifespan increased the number of people alive at any given time, requiring more production of food. Fortunately, Mr. Borlaug helped to solve that problem. But each accomplishment cited above, while solving one problem, had the potential to create other, unintended, problems.

The topic of the intercontinental ballistic missile and its nuclear weapons forms an example of an accomplishment that solved a then-current, urgent problem, but created serious unintended consequences afterward. Nuclear weapons were created by the United States during World War II because there was evidence that Nazi Germany itself was working on such weapons; if the Nazis succeeded and the United States did not have such weapons, the Nazis would likely have won the war. But having been created for a reasonable purpose (e.g., ensuring the defeat of the Nazis) did not prevent nuclear weapons from creating serious adverse unintended consequences. The hardest part of creating such nuclear weapons turned out to be realizing that it could be done; the actual engineering, while difficult, could over time be accomplished by any country with a modern industrial base. This meant that the United States could not expect to retain a monopoly on these weapons; other countries – not all of which were benign[11] – could be expected to create them after the war as well. The United States elected to adopt a policy of *deterrence*; that is, present the world with a credible capability to strike back even *after* a nuclear attack by any foreign country upon the United States, with the expectation that the existence of such a potential retaliatory capability would discourage any other country from attacking the United States.[12] In fact, deterrence has worked; in combination with other US policies (such as the Marshall plan to rebuild a Europe devastated by war, and full of people who were literally on the verge of starvation; the basing of US troops in Europe after the conclusion of the war; and the formation of NATO[13]), Europe has enjoyed the longest period in its history without a major war between European nations, and the United States and the USSR fought no war of *any* sort – nuclear or conventional – directly with each other. In my view, deterrence worked because it was implemented not just as a weapons

---

11 During World War II, and for several years after the conclusion of the war, the USSR was governed by Ioseb Dzhugashvili (better known by his adopted revolutionary name of Joseph Stalin), recognized as the second largest mass murderer in all of human history (sources are cited at the end of this footnote). Those who study these matters agree that Stalin killed significantly more people even than Adolf Hitler, the head of Nazi Germany. By 1948, shortly after the conclusion of World War II, China was governed by Mao Zedong (formerly spelled in English transcription as Mao Tse-Tung); those who study these matters recognize Mao Zedong as *the* largest mass murderer in history. It was not unreasonable to see the acquisition of nuclear weapons by such people as a significant threat to the world. Sources: https://www.quora.com/What-are-the-worst-genocides-and-mass-murders-in-the-history-of-humanity, https://www.theepochtimes.com/the-worst-mass-murder-of-all-time_2134122.html, and https://about-history.com/list-of-dictatorships-by-death-toll-the-top-10-biggest-killers-in-history.

12 There were alternative policies considered at the time too. To oversimplify a bit, these consisted of (i) having the United States abandon nuclear weapons and hope that Stalin and the others would follow this moral example, or (ii) attacking the USSR before it had a significant nuclear weapon capability of its own. Both of these alternative policies were rejected (in my view, correctly) as presenting untenable risks to the United States and to the world (and in the case of a preemptive attack on the USSR, also entailing poor morality). Deterrence was selected, with all of its risks, as being the least-bad alternative available. As we will also discuss later in the book, there is not always a perfect approach to solving a problem. Deterrence, of course, works both ways: the USSR presumably believed that its own nuclear and missile capabilities would deter the United States from attacking them.

13 The latter two policies were intended to break the 1,000-year cycle of continuous war between European nations. So far, they have (mostly) worked. This is a tremendous tribute to US President Harry Truman, his Secretary of State George Marshall (who advocated the creation of the Marshall plan), and Dean Acheson (who followed George Marshall as Secretary of State), who advocated and lead the creation of NATO.

program, but concurrent with efforts to understand the culture and decision processes of potential adversaries that might acquire nuclear weapons (starting with the USSR), so as to understand what actions would create a deterrent effect with those nations. A new risk to the world is that as additional nations elect to acquire nuclear weapons, we may not have the concomitant understanding of the cultural and decision processes of these new nuclear-armed nations.

When we get to Chapter 9, and I introduce my approach for dealing with low-probability but high-impact adverse events, you will likely conclude that deterrence is not a sufficient policy. We can discuss potential alternative and/or supplemental policies when we get to that chapter. US President Ronald Reagan introduced the only significant addition to the policy of deterrence since its original adoption, when he advocated adding the ability to defend against intercontinental ballistic missiles as an additional component of deterrence. As moral choice, adding such an ability to defend is without flaw. Missile defense is technically quite difficult, however, and it may be considered an open question of whether or not we have achieved a level of technical missile defense capability that can yet be considered a *credible* addition to deterrence.

Deterrence nearly failed in 1962, in the event known as the Cuban missile crisis. Most assessments that I have read agree that leadership – and the characteristics of the specific individuals involved – played a big role in this near-failure of deterrence. I like to think of this incident as showing the power of deterrence: it held, even in the face of specific individuals who displayed weak leadership.[14]

Leadership does in fact matter a great deal, as we will discuss many times in this book (most specifically, in Chapter 13).

14 In my view, the Cuban missile crisis was avoidable, and could have been settled by diplomacy, without recourse to threats of military action by the United States; trying to settle the crisis using only diplomacy was the course-of-action recommended by both the US Secretary of State and the US Secretary of Defense at the time: *The March of Folly*, Barbara Tuchman, 1984. It was the US President (John F. Kennedy) who insisted on threatening the use of military force, against the advice of his cabinet. The previous year (1961) had featured an incident known as the Bay of Pigs. Kennedy had openly stated that he was personally embarrassed by the poor way in which he handled the Bay of Pigs situation, and that he was not going to let himself be embarrassed again (for example, "After the Bay of Pigs … Kennedy was determined to stand fast," *Thirteen Days*, Robert F. Kennedy, 1969). Notice that Kennedy did not say that he would stand fast when justified by the facts of a situation, but instead he said that would stand fast so that Nikita Khrushchev (Chairman of the Communist Party of the USSR, and therefore the de facto head of the Soviet Government) would not think that Kennedy could be pushed around.
Robert F. Kennedy was President Kennedy's brother, and also the Attorney General of the United States.
President Kennedy also used frequently to brag that he intended always to show himself as "tough" – this was his own term. For example: "Kennedy asserted that 'I have to show him that we can be as tough as he is'" ("Bearing the Burden," Thomas Patterson, https://www.vqronline.org/essay/bearing-burden-critical-look-jfk%E2%80%99s-foreign-policy); "Kennedy seemed eager to prove his toughness once in office" (ibid.); "Journalist William V. Shannon, after reviewing the first few months of the new administration, concluded that it had established a cult of toughness" (ibid.); "… the policy of toughness became dogma" (ibid.); "Toughness was the tone" (*The March of Folly*, Barbara Tuchman, 1984); "One does not even have to rehash his relationship with Joseph McCarthy to show how JFK willingly played the 'tough on communism' issue in all his campaigns" ("John Kennedy and the Cold War", http://mcadams.posc.mu.edu/progjfk5.htm); "… while running for President in 1960, JFK appealed to the 'tough on the Soviets' issue" (ibid.). There are literally dozens of additional quotes from Kennedy about his desire to appear "tough." The desire to appear tough and the desire to avoid embarrassment are not (in my view) mature, appropriate bases for effective leadership; we will discuss better attributes of leadership in Chapter 13.
Even despite this weak leadership (on both sides; Nikita Khrushchev had his own weaknesses of leadership too), deterrence held.