Edward W. Merrow

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Concepts, Strategies, and Practices for Success

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Foreword

Will your megaproject be a success or a failure? Data from more than 300 global megaprojects shows that 65 percent of industrial projects with budgets larger than $1 billion in 2010 U.S. dollars failed to meet business objectives. In some industrial sectors the failure rate was as high as 75 percent. Most of the failed projects were unprofitable, but not all. Some made money due to a serendipitous increase in forecasted product prices or other unanticipated windfalls. Unfortunately, these projects support some people's belief that "it is better to be lucky than good" at what you do. However, if this isn't how you want to manage your business risks on very large investments, there is some really good news. For more than two decades, Independent Project Analysis, Inc., has been exploring what makes projects succeed and fail, and the results of their research on megaprojects are now available in this book.

Industrial Megaprojects is a primer on what to do and what not to do as part of end-to-end megaproject management. This book provides the necessary information for you to establish a decision and execution framework that allows you to be in control of your project's outcomes, not "just hope to be lucky." It is structured in a way that those who sponsor, direct, or work on large projects can gain a functional understanding of how best to achieve the most business-effective results. It also enables business executives who are genuinely in charge to make better decisions about how the project should be developed, governed, and executed. Most important, it lays out ways to overcome the largest challenge in successful implementation of megaprojects—enabling the business and technical professionals to work together collaboratively as a fully integrated team.

Now back to the critical question: Will your megaproject be a success or a failure? The answer is . . . it depends. It depends on whether you can positively answer these key questions:

- Will it be built and started up without injury to anyone involved, or will people be hurt or killed?
- Will the total cost be in line with the amount authorized, or will it exceed the estimate by more than 25 percent?
- Will it be completed on the original schedule, or will it slip by more than 25 percent?
- Will it start up and deliver the promised production, or will there be an initial or permanent shortfall?

How confident you are that you can accurately answer these questions depends on several things. The critical ones are: (1) Have you put the concepts, strategies, and practices—proved to deliver successful megaprojects—in place? and (2) Have you integrated them into a disciplined project management process? In addition, I would like to call to your attention what I, as well as the author, believe is the most important and almost unique requirement for a successful venture: the need to assess and then shape the opportunity into a reasonably stable platform from which to manage the project. Opportunity shaping is a process involving both the business and the technical professionals who would be assigned to the project. To be successful, it must be led by the senior business executive accountable for the financial performance of the business unit proposing the venture. It allows the sponsors to evaluate the key attributes of a potential project, gather information that is needed to guide venture level decisions, and then allocate the value to the various stakeholders. This will make the project environment stable enough for successful execution, while holding enough of the project's value for the sponsors to make the venture worthwhile. In this book, the opportunity shaping process is discussed from the perspective of the business and the project professionals who are working for the leading stakeholder-investor. Both the information that needs to be developed to make good shaping decisions and how to devise a successful shaping strategy are detailed. I believe this part of the book is a must-read for business and technical professionals

charged with the accountability of developing and successfully executing a megaproject. When business and technical professionals do not understand and then apply opportunity shaping concepts and strategies, the risk of their project being one of the 65 percent failures is extremely high.

After more than 40 years working in the capital project arena, I remain mystified by the extreme reluctance of very intelligent business and technical leaders to pay attention to validated past experience. It is my opinion that failing to accept that there are project best concepts, strategies, and practices that, when executed in a disciplined manner, deliver predictably good results makes no business sense. Over the course of my career, I have struggled to find the right way to communicate this and show that the business value was so obvious that the use of the proven approaches should be a no-brainer. But, until now I have been woefully unsuccessful, even on projects for businesses that have experienced failures in the past. I had begun to fear that we were all destined to continue to validate the observation expressed in this quote from Douglas Adams, English humorist and science fiction novelist:

> *Human beings, who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so.*

However, knowing that the knowledge contained in this book is now available to everyone makes me cautiously optimistic. I am truly hopeful that this book will become the "megaproject handbook" and be required reading for all business and technical leaders currently working on or contemplating a venture that would include a large capital investment. Looking to the future, I recommend this book become the primary text for all college and professional development courses on venture and project administration and management. This would contribute significantly to current and future business and technical leaders being much better prepared to plan and execute successful projects regardless of size.

I know as business and technical professionals there is always a great demand on your time, but now that you've read this far, I strongly

encourage you to read all of this book. The key concepts, strategies, and practices are described in actionable terms, and their business value is supported by actual project examples. I'm certain you'll agree that your investment of a few hours reading this book and discovering how you can potentially save billions in project costs will have a huge return.

—James B. Porter, Jr.
Chief Engineer and Vice President (Retired)
Engineering and Operations
E.I. DuPont & Company

Acknowledgments

My first and deepest thanks must go to the megaproject teams that patiently answered thousands of questions about their projects. Without their time and candor, there would be no data to examine and no stories to tell. I also thank my colleagues at Independent Project Analysis, Inc., who asked the questions, probed the responses, and evaluated the individual projects. I hope they will see the fruits of their fine efforts reflected in the book. My special thanks go to my research colleagues Kelli Ratliff and Luke Wallace. Kelli worked closely with me several years ago in the development of the first megaprojects course for the IPA Institute. Luke did a remarkable job providing me with needed data as I wrote the book; his timeliness was essential to the schedule.

While writing the book, I was very fortunate to have a splendid set of reviewers. My IPA colleague, Paul Barshop, read and commented on most of the chapters and provided an insider's expertise while commenting on the analysis. I also had five external reviewers who gave of their time and expertise to review and comment: Joseph Brewer, megaproject manager extraordinaire at the Dow Chemical Company; Drew McCullin, Director of DuPont Capital (ret.); Jim Porter, Chief Engineer and Vice President (ret.), DuPont Company; Iain Smith, formerly Director of Capital Projects, Imperial Chemical Industries, Ltd; and Maggi Walker, Vice President, Engineering Solutions and Technology Centers, Dow Chemical Company. Each reviewer provided a distinct point of view and improved the book at every turn. Mike Loulakis, a very rare lawyer who deeply understands projects, provided a great review of Chapter 11, which deals with contracting. Any mistakes likely resulted from my not heeding their good advice.

It is to my most important reviewer, critic, and friend, my wife, Loretta, that I dedicate this book in thanks for her unstinting encouragement.

INTRODUCTION

Why Megaprojects Fail So Often
Seven Key Mistakes

By way of introducing you to the strange world of megaprojects, I am starting by discussing seven critical mistakes that I have seen most often in my 30 years of studying these projects, first at The Rand Corporation and then for the past 23 years at Independent Project Analysis (IPA). If you are responsible for a megaproject right now, try to ask yourself, "Am I now in the process of making one of these whopper blunders?"

After outlining how to do large projects well to the executive committee of a large company, the chief executive officer (CEO) asked me an obvious question: "Given that all of this is rather straightforward," (he actually said "smashingly banal"), "why can't we do it?"

The answer was one he anticipated and feared: "Because you are incapable of generating the kind of deep cooperation within the company that is necessary to do these projects well."

Most of the big mistakes that companies make in developing and executing these projects stem from a basic lack of being able to pursue a common goal with clarity and good behavior.

This book is mostly about mistakes, often masked with the bravado of "taking daring risks," but in the end just plain mistakes. So I thought it appropriate to start our discussion of megaprojects with seven whopper mistakes that doomed too many of these projects from the start. For the most part, the engineers on these projects tend to make little mistakes, although some of them occasionally cascade into disaster. Most big mistakes are made by senior business managers in the sponsoring firms. The reason they make most of the big mistakes

is because they have control of the things that matter most: strategy, money, and people. In most megaproject developments, the most important single relationship among the many thousands of relationships involved is the one between the business director for the project and the project manager, often called the project director.

So here are my top "Sorry Seven":

1. **I want to keep it all!**

   In days of yore, greed was considered a bad thing, even in business, because greed was liable to get us into trouble. I am pleased to report that in megaprojects, greed still works that way. When companies approach these projects with a view of trying to take as much of the pie as they possibly can, they lose sight of an essential element in making the project succeed: the allocation of the project's potential value in a way that provides a stable foundation on which the project can be executed. This will be a primary subject of Chapters 4 and 5. Working a deal that will be seen as essentially unfair to other stakeholders will tend to backfire. Greed generates an imbalance in the distribution of costs and rewards of the project.

   Most commonly, a project with a greedy lead sponsor falls apart in the development (shaping) phase, so we end up with nothing rather than all of it. In other cases, the project proceeds, but those who believe they have been treated unfairly never let go of their opposition. They then add turbulence to the project environment, giving project directors more trouble than they can manage. By their nature, megaprojects often struggle with turbulent project environments. Adding to that turbulence is a recipe for failure.

2. **I want it *NOW*!**

   Schedule pressure dooms more megaprojects than any other single factor. When there is pressure to move a project along quickly from the outset, corners get cut and opportunists have a field day.

   A classic case was a group of difficult deepwater petroleum developments that was put on a fast track when the CEO mentioned in a meeting with the financial community that the projects

would go into production on a particular date. The project community's reaction within the company was, "It can't be done!" But that didn't deter an ambitious vice president who saw an opportunity to ingratiate himself with the boss. He then set up a "daring and ambitious" program with an inexperienced contractor to deliver the projects in 70 percent of industry average time at 70 percent of industry average cost. The result was a program overrun of numerous billions of dollars, and a full four-year delay on the company's largest and most important project.

No project should ever be deliberately slow. (If it really doesn't make any difference when the project is completed, you probably shouldn't be doing the project now anyway.) But taking risks with megaproject schedules is a fool's game. Every megaproject has an appropriate pace at which the project can be developed and executed successfully. Furthermore, that pace is known with a fair degree of confidence early on if good practice is followed. If the economics of the project require an accelerated schedule, then the appropriate conclusion is that the project is uneconomic and should not be done. Unlike smaller projects, megaprojects cannot be used to "fill in a gap" in your production or "meet a market window." When the calendar rather than the needs of the project drives the schedule, the project fails. We return to the issue of fast-tracking megaprojects in Chapter 5.

3. **Don't worry; we'll work out the details of the deal later.**

As a megaproject director friend of mine likes to say: "The deal drives the project; the project can't drive the deal!" I would add that the project *can* drive the deal, but it never turns out to be a *good* deal. The business deal and the project have to develop together and inform each other, but the deal governs. The deal establishes the parameters and the priorities for the project. The deal determines the relative importance of capital cost versus operating cost and cost versus schedule. The deal also determines how big the scope can be.

Many megaprojects center around a deal between a resource holder (e.g., petroleum, minerals deposit) and a company with the technical expertise to develop that resource and sell the product. The basic contours of the deal between the resource holder

and the resource developer must be decided quite early in the front-end development of the project. The deal is what will ultimately shape how money will be made, as well as how it will be divided. In the absence of the deal, the project is directionless. If project development continues without the deal informing its shape, the chances that the deal will never be struck increase. Furthermore, if the potential partners cannot agree fairly quickly on the shape of the deal, there may be something terribly amiss. Let me cite an egregious example.

A European company was developing a large project (~$7 billion) in the Middle East with a resource holder. The idea was that the resource holder would provide the feedstock at a discounted rate to promote industrialization and job creation; while the project was busy being developed and defined, the negotiations over the formula for this went nowhere. When we challenged the rationality of this situation with the company executive driving the deal, we were brushed aside with a "You don't understand the Middle East." Finally, the invitations to bid were issued and more than $250 million of the company's money had been spent and the board of directors finally required a deal or no authorization. When there was no deal forthcoming, the company was forced to cancel the project and eat the loss. What was going on? The resource holder didn't actually have the feedstock, and exploration efforts were coming up empty. Not wanting to lose face (and make their resource situation known to the world), they dragged their feet until the sponsor quit. They then publicly blamed the sponsor for killing the project and being an unreliable and untrustworthy company! And who is it exactly that doesn't know the Middle East?

4. **Why do we have to spend so much up front?**

Every project professional worthy of the title knows that skimping on the front-end definition of a project is stupid. So when it comes to the biggest and most important projects that we do, we routinely skimp on the front end. Megaprojects—with so much at stake—are routinely less well defined at authorization than smaller, less important projects. The primary reasons are time (see Mistake 2) and money (see Mistake 1).

Depending on the specifics of the project, doing a thorough job defining and planning an industrial megaproject takes 3 to 5 percent of eventual total capital cost. Let's be clear; on a megaproject that is a lot of money. The cost, however, of *not* spending the money is much, much more.

Senior managers are understandably concerned that if they spend, say, $100 million and the project is canceled, they are stuck with the bill. Even worse from their perspective, the $100 million is expense, not capital, and is therefore deducted immediately from earnings. However, when senior managers are faced with this situation as a realistic possibility, it is symptomatic of other problems.

Sometimes managers find themselves in this risk of loss position because the resource holder has deliberately set them up. Some resource holders want no decision points between the initial "memorandum of understanding" (which has no binding effect) and the full-funds authorization of the project. This is a simple bargaining ploy: The resource holder believes that if they can get the sponsors to spend enough money, the sponsors will be locked into the project whether or not they really want to be. This is a psychological example of the forward-going economics trap—that is, "throwing good money after bad."

At other times, senior managers can find themselves in this dilemma because the cost of the project was not understood at the necessary and appropriate time. As we discuss at some length in Chapter 4, the eventual cost of the project should be known with a fair degree of assurance when only about 1 percent of total cost has been expended, not 3 to 5 percent. If management doesn't have the stomach for spending 1 percent as pure risk money, they should not play the game. Spending that front-end money well is the subject of Chapter 10.

5. **We need to shave 20 percent off that number!**

One of the most counterproductive exercises in megaprojects is the "cost reduction task force" responding to management's admonition to significantly reduce the cost of the project, usually within a few months of full-funds authorization. I have literally heard a vice president say, "You guys [meaning the project

team] need to sharpen your pencils and get a billion dollars out of that estimate!" Those must be magic pencils, because in the real world, the cost of a project is inextricably linked to its scope, which in turn is a reflection of its intended functionality. Unless I change the scope, which means that some functionality has to give way, I cannot really change the cost estimate. But to change the scope would require another year or two before we are ready to authorize the project, which is, of course, unacceptable because of Mistake 2.

So project teams in this situation do one of two things: they change the assumptions underlying the estimate such as the cost and productivity of labor, prices for equipment, and so on, or they actually cut the scope knowing that it will all have to come back later to achieve the needed performance of the project. Either way, they are headed for a big overrun, and the savviest among them will be preparing to post their resumes so as not to be caught up in the scapegoating that will surely occur later.

6. **The contractors should carry the risk; they're doing the project!**

A majority of megaprojects in most parts of the world are executed on some form of fixed-price contracts between the sponsors and one or more prime contractors. Rather than project professionals, the preference for fixed-price (lump-sum) contracting almost always comes from the business leadership or from the banks financing the projects. Their belief is that the contractual form will transfer the cost (and often schedule) risk from the sponsors to the prime contractor(s). And every once in a while, it actually does! Most of the time, however, relatively little risk is actually passed, but a substantial premium is paid nonetheless.

There is a simple and unavoidable problem with wholesale risk transfer from sponsors to contractors: the contractors cannot actually carry the risk on a megaproject. The firms that engineer and construct industrial projects are variable-cost firms with very little in the way of fixed assets. Their balance sheets are not loaded with capital assets, and generally the cash they have on the balance sheet is needed for working purposes. They earn by

selling the services of people rather than via the production and sale of products. This simply means they cannot possibly carry the kinds of losses that can and do occur on megaprojects. As a consequence, given the preference of business leaders and banks for lump-sum contracts, the engineering and construction firms have become very adept at taking on lump-sum contracts with loopholes or bidding so high that the risk is manageable.

Most of Chapter 11 takes up the issue of how to match the contracts to the situation rather than the situation to the contracts. However, the belief that lump-sum contracts establish a ceiling on what sponsors will pay for a project is to completely confuse a ceiling and a floor. No sponsor has ever paid *less* than the value of the lump-sum contract, but many, many a sponsor has paid much more.

7. **Fire those #$@$^! project managers who overrun our projects!**

   Beating up project managers who overrun capital projects is a blood sport that certainly dates back to the Great Pyramids. However, it's a bit of fun that comes with a very high price tag for the business.

   I have been looking at capital projects now for more than 30 years. I have met hundreds of project directors and managers of all sorts and descriptions. I have yet to meet one who starts the day by asking, "What can I do today to screw up my project?" I have met some project directors who struck me as hopelessly incompetent, but very few of those were working on megaprojects. Large cost overruns on major projects can almost never be honestly laid at the door of the project director.

   I will never forget a very long morning I spent with the CEO of a large international oil company. Much of our discussion that morning focused on why it was inappropriate and counterproductive for him to personally browbeat project managers who overran their projects. I finally concluded the discussion this way: "If you beat up the project managers for overruns, they will find ways to hide money so you can never find it. If they don't, you have hired a bunch of morons. And morons don't do projects well either!" As I walked down the corridor after the

meeting, the vice president responsible for exploration and production turned to me and said, "Ed, now you see what we're up against." I left that day knowing that I had lost the argument, and 15 years later, the company's engineering department, led by a former contractor, focuses most of its effort on finding where the project directors have hidden the money.

The previous seven megamistakes are not mutually exclusive; they can and do show up together in many combinations. However, any one is usually sufficient to doom a project to failure.

PART ONE

Understanding the Projects

CHAPTER 1

Megaprojects—Creators and Destroyers of Capital

If you have spent much time hiking in the woods, you have probably had that uncomfortable occasion when, after walking for several hours, perhaps chatting with a friend along the way, you suddenly realize you have absolutely no idea where you are or how long it has been since you knew where you were. Many a megaproject director has encountered that same feeling while trying to bring a large and complex project safely home. This book seeks to explain how and why we so often find ourselves lost when trying to develop and execute very large industrial projects. If we can understand how and why we tend to get lost, we will better recognize when we are leaving the trail, find our way back if we do get lost, or at least know when to plead for directions.

Industrial corporations create their capital assets primarily through projects. The first decade of the twenty-first century has seen more very large and complex projects executed by the process industries—oil, chemicals, minerals, and power—than any comparable period in human history. These projects satisfy the world's demand for energy, metals, chemicals, and other products. Without them, modern society as we know it could not exist.

Projects have increased in size and complexity for a number of reasons: easily accessed resources close to markets have largely been depleted; international oil companies must venture into deep water and other difficult environments because national resource holders control more easily developed oil and gas; and chemical companies seeking lower-cost feedstocks need to exploit economies of scale to

compete globally and often must go to the source of the feedstocks to make the project viable. The need for extensive infrastructure development means that many projects will have to be very large to spread the infrastructure costs over a wide enough base of beneficial production to be economic.

As the projects have increased in size and complexity, they have become much more difficult to manage. Cost overruns, serious slips in completion schedules, and operability problems have all become more common. Many of these very large projects end up being disappointing to their sponsors; a fair number turn out to be massive destroyers of shareholder wealth; and a few are horrendous with respect to anything and everything involved—the investing companies, the local population, and the environment. When megaproject disasters become public knowledge, which is rarely the case, they damage reputations and even jeopardize continued existence.*

The research program of Independent Project Analysis, Inc. (IPA) on megaprojects over the past five years shows clearly that virtually all of the poor results of these projects constitute self-inflicted wounds. The sponsors are creating the circumstances that lead inexorably to failure. *And that is profoundly good news!* Problems we cause ourselves, we can fix.

WHO SHOULD READ THIS BOOK?

Anyone with responsibility for large, complex, or difficult capital projects will find things of interest in the pages that follow. My particular goal is to help those who sponsor, direct, or work on large projects guide the projects to safe and successful outcomes. My special focus is on what I call "industrial megaprojects"—very large projects sponsored by the petroleum, chemicals, minerals, power, and related industries.

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*The failure of BHP's Hot Briquetted Iron Project in 1999 contributed to the company losing more than half of its market value. The $10-plus billion overrun of Shell Sakhalin-2 Project damaged Shell's reputation and created an excuse for the Kremlin to nationalize a large portion of the project. The structural failure of BP's Thunder Horse semi-submersible platform in 2005 in the U.S. Gulf of Mexico was an important element in a series of stunning setbacks for the company. Most megaproject disasters, however, remain carefully private—while sometimes wearing a very different and well-contrived public face.

Anyone interested in complex projects, even if they fall far short of megaproject status, will find the story of these projects informative to their situation. Most of the basic principles of doing megaprojects well are the basic principles of doing all projects well. Megaprojects display some attributes that are common to megaprojects and uncommon in smaller projects, and we will focus our attention on those. But if the reader is interested in projects, megaprojects will always be fascinating.

I very much hope that members of boards of directors of companies that sponsor megaprojects read this book. To be blunt, when it comes to the governance of large projects, most boards strike me as brain dead. They are not asking the right questions, and they are not asking questions early enough in the process to deter bad decisions.

Those who finance major projects should find a great deal of interest (forgive the pun) in the book. In many respects this book is all about large project risk, which is a key concern for banks and others involved in project finance. It is my observation that bank financing often increases cost while doing nothing whatsoever about project risk.

Those who are concerned about the management of the modern publicly owned industrial corporation and teach others about how it should be done will also find this book interesting, and perhaps very disturbing. The failure of these projects is symptomatic of the core problems of the modern firm: too much outsourcing of key competencies, poorly informed decision making, a woeful lack of accountability for results, and a pathological focus on the short term at the expense of the long-term health of the corporation and its shareholders.

WHAT IS AN INDUSTRIAL MEGAPROJECT?

The projects that are the subject of our research are a subset of all projects and even a subset of large projects. We focus on *industrial* megaprojects. By *industrial,* we mean projects that make a product for sale, for example, oil, natural gas, iron ore, nickel, gold ingot, diamonds, and high-volume chemicals. All of the projects under scrutiny were intended to make an economic profit, at least eventually,

for some if not always all of the sponsors.* By confining ourselves to industrial projects, we have excluded several classes of important projects: military developments, purely public works and transportation projects, monuments, works of art, and so forth. By excluding these sorts of projects we have excluded some megaprojects from our analysis. We have a couple of reasons for doing so:

- Confining ourselves to projects that are intended to make money simplifies the task of assessing outcomes, not necessarily simplifying the range and complexity of objectives in the projects. Although it is true for almost all of our projects that *someone* wanted and expected to make money on the result, it does not follow that *all* of the sponsors expected to make an economic profit. Some were motivated by jobs creation, political ambition, general economic development, and other "public" goals. These "mixed motive" projects as we call them are an interesting class and pose challenges for for-profit sponsors.
- Having some economic profit motive disciplines and constrains the objectives of the projects in important ways. Some public works projects have objectives that are hard to fathom by mere mortals. Some military acquisition programs appear to continue almost solely on the strength of political patronage long after the military rationale has become obsolete or discredited.† And some "prestige projects," such as the Concorde supersonic transport, have objectives that must forever be in the eye of the beholder. Who is to say whether prestige has actually been enhanced, and was it by an amount sufficient to justify the opportunity cost of the project? Industrial projects tend to have at least some nicely tangible objectives.

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*A few of our projects were undertaken with the explicit expectation that they would make little or no economic profit but would facilitate highly profitable projects later. These projects bear the dubious title "strategic," a subject to which we return in Chapter 4. The term *sponsor* is reserved for those organizations that claim formal ownership of a project by virtue of their economic investment in the project. Those investments could occasionally be in-kind or deferred but usually indicate monetary investment in the cost of the project.

†For example, long after a superior option had emerged, the U.S. Air Force B-1 Bomber program continued due entirely to political influence. "B-1 Problems, if reparable, could cost $3Billion," the *Boston Globe,* February 13, 1987. The V-22 Osprey aircraft program not only overran its budget colossally, but it also suffered repeated crashes . . . but continued anyway. "Assessments Needed to Address V-22 Aircraft Operational and Cost Concerns to Define Future Investments," GAO-09-482, May 2009.

What makes an industrial project an industrial *mega*project? Megaprojects, as the name implies, are very large. To provide a simple and simply applied definition, we are defining a megaproject as any project with a total capital* cost of more than $1 billion (U.S. dollars) as measured on January 1, 2003. In 2010 nominal dollar terms, that would amount to about $1.7 billion due to the effects of rapid escalation in project costs in the last decade. One can reasonably object that this definition is simplistic; it totally disregards the effects of complexity (however measured) and the project environment on whether the project is a megaproject. The objection is noted but must be dismissed. If we include consideration of aspects other than size in our definition, we forfeit the ability to examine the effects of those aspects on the outcomes and management of our projects. One can also most certainly object that the $1 billion criterion is completely arbitrary. Why not $500 million or $2 billion? Yes, the $1 billion figure is arbitrary, but it is somewhat less arbitrary than it may seem. In the neighborhood of a billion dollars is where we see project outcomes begin to deteriorate sharply.

WHY STUDY THESE PROJECTS?

There are four compelling reasons to study and understand megaprojects:

1. There are many more of them than in times past, and this will continue for decades to come.
2. These projects are important. They are important to the societies in which they are being done; they are important to the health of the global economy; they are important to the sponsors and others putting up huge amounts of money.

*By capital we mean the costs for materials, engineering, and construction labor associated with completing a project. We exclude venture costs associated with setting up the permanent operating organization at the site or in some cases for the new company. In frontier environments, these venture costs can be quite substantial, in some cases more than 20 percent of the capital costs of the venture. We also do not explicitly evaluate operating costs, although we do keep track of when operating costs end up substantially higher than expected in these projects. The sponsors should, of course, be looking at total costs of the venture and should do so on a life-cycle basis to the extent that the data permit.

3. These projects are very problematic. They are failing at an alarming and unsustainable rate.
4. There is not much published that speaks directly to the types of projects considered here.

I will discuss each of these reasons to worry about megaprojects in turn.

Increasing Numbers

Industrial megaprojects have become much more common. For much of the 1980s and virtually all of the 1990s, there were few very large projects, even in the petroleum industry. The Norwegian and UK North Sea had been home to a number of megaprojects in the 1970s. These projects had a very difficult go, and without the rapid rise in crude oil prices in the wake of the overthrow of the Shah of Iran, almost none of the megaprojects in the North Sea would have been profitable ventures.[1] Most of the megaprojects that had been in planning stages in the late 1970s died abruptly when commodity prices fell in the early 1980s.

However, a number of factors have converged to make megaprojects much more common in the first decades of the twenty-first century, and these factors give every indication of being enduring drivers of very large projects. The first factor driving the current wave of megaprojects has been the rapid rise in the demand for almost all major commodities; iron ore, coal, copper, and petroleum have all experienced very rapid increases in demand (and therefore price) since 2003. Previously, most prior commodity price fluctuations had not been synchronized; prices might rise for one or two metals, oil and gold prices might rise for political reasons, but not all at the same time. The underlying common driver this time was the rapid industrialization of China and India in the context of reasonable overall global growth. None of the major commodities are actually facing imminent global depletion; however, most are facing upward sloping long-run marginal costs.

The different commodities have had somewhat different drivers for large projects:

- Opening up a new major mineral ore body has long been expensive. Most major new mines today are in places that require major