Introduction: The Iron Law of Megaproject Management

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Abstract

Megaprojects are large, they are constantly growing ever larger, and more and more are being built in what has been called the biggest investment boom in history. This chapter serves as an introduction to megaprojects, and to *The Oxford Handbook of Megaproject Management*. First, megaprojects are defined and the size of the global megaprojects business is estimated. Second, drivers of the megaproject boom are identified, including monumentalism and the technological sublime. Third, ten things you must know about megaprojects are detailed, from their tendency to suffer from uniqueness bias to their overexposure to black-swan events. Fourth, the "iron law of megaprojects" is identified as a main challenge to megaproject management: "Over budget, over time, under benefits, over and over again." Finally, the main structure of the *Handbook* is set out as covering the *what*, the *why*, and the *how* of megaproject management, in terms of the challenges, causes, and cures that students of megaprojects must decipher to better understand and better manage megaprojects.

Keywords: Megaprojects, scaling, infrastructure, megaproject management, management, decision making, cost-benefit analysis, cost overruns, benefit shortfalls, optimism bias, strategic misrepresentation

Classics in Megaproject Management

The ambition for this inaugural edition of *The Oxford Handbook of Megaproject Management* is to become the ultimate source for state-of-the-art scholarship in the emerging field of megaproject management. The book offers a rigorous, research-oriented, up-to-date academic view of the discipline based on high-quality data and strong theory. Until lately, the literature in this new field was

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scattered over a large number of publications and disciplines making it difficult to obtain an overview of the history, key issues, and core readings. *Megaproject Planning and Management: Essential Readings, Vols. I-II* (Flyvbjerg 2014a) assembled the key historical texts in the field. *The Oxford Handbook of Megaproject Management* has been designed to provide the most important contemporary readings. Taken together, the two books are intended to map out the best of what is worth reading in the megaproject management literature, past and present.

In a recent survey, the author asked 114 experts to identify the classics in megaproject management (Flyvbjerg, 2014b: xxx-xxxi). The results show that if one defines a "classic" in the conventional sense – as a written work that is generally recognized as definitive in its field by a majority of experts in that field – then there are no classics in megaproject management. Remarkably, the publication proposed by the most respondents as a classic was proposed by only five respondents, several times less the required majority for a classic. In no less than 79 percent of cases, a publication put forward as a classic was proposed by one and only one respondent, indicating a huge spread in views regarding what the classics might be in this field.

Several explanations exist for this lack of consensus regarding classics in megaproject management. The field is young and unconsolidated as an academic discipline; therefore perhaps more time is needed to develop and agree upon possible classics. Moreover, the field is multidisciplinary and fragmented, which makes consensus harder to come by. Whatever the explanation, Kuhn (2012) and other philosophers of science hold that classics are necessary to develop and strengthen an academic field, because classics serve as exemplars and reference points around which paradigmatic research may evolve and against which revolutionary research can pit itself. Following Kuhn et al., it is argued here that megaproject management, if it is to make progress as an academic field of inquiry and a professional field of practice, is very much in need of classics. *The Oxford Handbook of Megaproject Management*, together with the previous book of historical texts, have therefore been developed with the explicit purpose of contributing to the growth of such classics, and hopefully one or more papers in the books may one day become classics.

In addition to the print version of *The Oxford Handbook of Megaproject Management*, an electronic version is planned to ensure the widest possible dissemination and to allow updates as new research appears.[1] The primary audience for the book is the research academic community, professionals, doctoral students, master's programs, and executive education programs in management, strategy, planning, megaproject management, and project and program management. It is hoped that by providing the present set of cutting-edge contemporary readings in megaproject management the book will help progress the discipline, academically and professionally. It is also hoped that citizens and communities interested in and affected by megaprojects may find useful insights in the book.

What Are Megaprojects?

Megaprojects are large-scale, complex ventures that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people.[2] Hirschman (1995: vii, xi) calls such projects "privileged particles of the development process" and points out that often they are "trait making," that is, they are designed to ambitiously change the structure of society, as opposed to smaller and more conventional projects that are "trait taking," i.e., they fit into and follow pre-existing structures and do not attempt to modify these. Megaprojects, therefore, are not just magnified versions of smaller projects. Megaprojects are a completely different breed of project in terms of their level of aspiration, stakeholder involvement, lead times, complexity, and impact. Consequently, they are also a very different type of project to lead. You do not want conventional project managers to lead megaprojects, but instead reflective practitioners (Schön 1983) who have developed deep domain experience in this specific field.

Megaprojects are increasingly used as the preferred delivery model for goods and services across a range of businesses and sectors, like infrastructure, water and energy, information technology, industrial processing plants, mining, supply chains, enterprise systems, strategic corporate initiatives and change programs, mergers and acquisitions, government administrative systems, banking, defense, intelligence, air and space exploration, big science, urban regeneration, and major events (Lenfle and Loch, chapter 2; Siemiatycki, chapter 3). Examples of megaprojects are high-speed rail lines, airports, seaports, motorways, disease or poverty eradication programs, hospitals, national health or pension ICT systems, national border control, national broadband, the Olympics, large-scale signature architecture, dams, wind farms, offshore oil and gas extraction, aluminum smelters, the development of new aircrafts, the largest container and cruise ships, high-energy particle accelerators, and the logistics systems used to run large supply-chain-based companies like Apple, Amazon, and Maersk.

To illustrate just how big megaprojects are, consider that in dollar terms some of the largest projects are as big as the GDP of many nations, as we will see below. Or take one of the largest dollar figures from public economic debate, the size of US debt to China. This debt is just north of a trillion US dollars and is considered so large it may destabilize the world economy if it is not managed prudently. With this supersize measuring rod, now consider the fact that the combined cost of just two of the world's largest megaprojects – the Joint Strike Fighter aircraft program and China's high-speed rail project – is more than half of this figure. The cost of a mere handful of the world's largest megaprojects will dwarf almost any other economic figure, and certainly any investment figure. Finally, consider that in delivering a megaproject one has to – over a relatively short period of time – set up, run, and take down a temporary organization that is often the size of a billion-dollar corporation. The size of megaprojects is staggering no matter what you compare with, and is matched only by the challenges of managing one.

[Figure 1 app. here]

But megaprojects are not just large, they are constantly growing ever larger in a long historical trend with no end in sight. When New York's Chrysler Building opened in 1930 at 319 meters it was the tallest building in the world. The record has since been surpassed seven times and from 1998 the tallest building has significantly been located in emerging economies with Dubai's Burj Khalifa presently holding the record at 828 meters. That is a 160 percent increase in building height over 80 years. Similarly, the longest bridge span has grown even faster, by 260 percent over approximately the same period. Measured by value, the size of infrastructure projects has grown by 1.5 to 2.5 percent annually in real terms over the past century, which is equivalent to a doubling in project size two to three times per century (author's megaprojects database). The size of ICT projects, the new kid on the block, has grown much faster, as illustrated by a 16-fold increase from 1993 to 2009 in lines of code in Microsoft Windows, from five to 80 million lines. Other types of megaprojects, from the Olympics to industrial projects, have seen similar developments. Coping with increased scale is therefore a constant and pressing issue in megaproject management, as emphasized by Ansar et al. (chapter 4). With increasing scale comes increasing globalization, and a set of institutional issues related to this (Levitt and Scott, chapter 5).

"Mega" comes from the Greek word "megas" and means great, large, vast, big, high, tall, mighty, and important. As a scientific and technical unit of measurement "mega" specifically means a million. If we were to use this unit of measurement in economic terms, then strictly speaking megaprojects would be million-dollar (or euro, pound, etc.) projects, and for more than a hundred years the largest projects in the world were indeed measured mostly in the millions. This changed with the Second World War, Cold War, and Space Race. Project costs now escalated to the billions, led by the Manhattan Project (1939-46), a research and development program that produced the first atomic bomb, and later the Apollo program (1961-72), which landed the first humans on the moon (Morris, 1994; Flyvbjerg, 2014b). According to Merriam-Webster, the first known use of the term "megaproject" was in 1976, but before that, from 1968, "mega" was used in "megacity" and later, from 1982, as a standalone adjective to indicate "very large."

Thus the term "megaproject" caught on just as the largest projects technically were megaprojects no more, but, to be accurate, "gigaprojects" – "giga" being the unit of measurement meaning a billion. However, the term "gigaproject" never caught on. A Google search reveals that the word "mega project" is used 80 times more frequently on the web than the term "giga project".[3] For the largest of this project type, costs of 50-100 billion dollars are now common, as for the California and UK high-speed rail projects, and costs above 100 billion dollars not uncommon, as for the International Space Station and the Joint Strike Fighter. If they were nations, projects of this size would rank among the world's top 100 countries measured by gross domestic product, larger than the economies of, for example, Kenya or Guatemala. When projects of this size go wrong, whole companies and national economies are affected.

"Tera" is the next unit up, as the measurement for a trillion (a thousand billion). To illustrate how the numbers scale, consider that a million seconds ago, compared to the present, is 12 days in the past; a billion seconds is 32 years in the past; and a trillion seconds is 31,710 years in the past, or the equivalent of several ice ages. Recent developments in the size of the very largest projects and programs indicate we may presently be entering the "tera era" of large-scale project management. Due to large cost overruns, the Joint Strike Fighter program looks to become the first stand-alone "teraproject" in human history, measured on life-cycle costs (United States Government Accountability Office 2012). Similarly, if we consider as projects the stimulus packages that were launched by the United States, Europe, and China to mitigate the effects of the 2008 financial and economic crises, then these are teraprojects, too. Finally, if the major acquisition program portfolio of the United States Department of Defense – which was valued at 1.6 trillion dollars in 2013 – is considered a large-scale project, then this, again, would be a teraproject (United States Government Accountability Office, 2013: 2). Projects of this size compare with the GDP of the world's top 20 nations, similar in size to the national economies of for example Australia or Canada. There is no indication that the relentless drive to scale is abating in megaproject development. Quite the opposite; scale seems to be accelerating. Megaprojects are growing ever larger.

How Big Is the Global Megaprojects Business?

But megaprojects are not only large and growing constantly larger, they are also being built in ever greater numbers at ever greater value. The McKinsey Global Institute (2013) estimates global infrastructure spending at USD 3.4 trillion per year 2013-2030, or approximately four percent of total global gross domestic product, mainly delivered as large-scale projects. *The Economist* (June 7, 2008: 80) has similarly estimated infrastructure spending in emerging economies at USD 2.2 trillion annually for the period 2009-2018.

To illustrate the accelerated pace at which spending is taking place, consider that in a recent five-year period, China spent more on infrastructure in real terms than in the whole of the 20th Century (Flyvbjerg 2014b). That is an increase in spending rate of a factor twenty. Similarly, in a recent four-year period, China built as many kilometers of high-speed rail as Europe did in two decades, and

Europe was extraordinarily busy building this type of rail during these years (Ren, chapter 7). Not at any time in the history of mankind has infrastructure spending been this high measured as a share of world GDP, according to *The Economist*, who calls it "the biggest investment boom in history." And that's just infrastructure.

If we include the many other fields where megaprojects are a main delivery model – oil and gas, mining, aerospace, defense, ICT, supply chains, mega events, etc. – then a conservative estimate for the global megaproject market is USD 6-9 trillion per year, or approximately eight percent of total global gross domestic product. For perspective, consider this is equivalent to spending five to eight times the accumulated US debt to China, *every year*. That's big business by any definition of the term. – Moreover, megaprojects have proven remarkably recession proof. In fact, the downturn from 2008 helped the megaprojects business to further grow by showering stimulus spending on everything from transportation infrastructure to ICT. From being a fringe activity – albeit a spectacular one – mainly reserved for rich, developed nations, megaprojects have recently transformed into a global multi-trillion-dollar business that affects all aspects of our lives, from our electricity bill to what we do on the Internet to how we work and shop and commute.

With so many resources tied up in ever-larger and ever-more megaprojects, at no time has the management of such projects been more important. The potential benefits of building the right projects in the right manner are enormous and are only equaled by the potential waste from building the wrong projects, or building projects wrongly. Never has it been more important to choose the most fitting projects and get their financial, economic, social, and environmental impacts right. Never has systematic and valid knowledge about megaprojects therefore been more important to inform policy, practice, and public debate in this very costly area of government and business. The *Oxford Handbook of Megaproject Management* is dedicated to delivering such knowledge.

Ten Things You Must Know about Megaprojects

What drives the megaproject boom described above? Why are megaprojects so attractive to decision makers? The answer to these questions may be found in the so-called "four sublimes" of megaproject management. The first of these, the "technological sublime," is a term variously attributed to Miller (1965) and Marx (1967) to describe the positive historical reception of technology in American culture during the nineteenth and early twentieth centuries. Frick (2008) introduced the term to the study of megaprojects and here describes the technological sublime as the rapture engineers and technologists get from building large and innovative projects with their rich opportunities for pushing the boundaries for what technology can do, like building the tallest building, the longest bridge, the fastest aircraft, the largest wind turbine, or the first of anything (see also Miller et al., chapter 10; Holzmann et al., chapter 20). Frick applied the concept in a case study of the multi-billion-dollar New San Francisco-Oakland Bay Bridge, concluding "the technological sublime dramatically influenced bridge design, project outcomes, public debate, and the lack of accountability for its [the bridge's] excessive cost overruns" (239).

Flyvbjerg (2012, 2014b) proposed three additional sublimes, beginning with the "political sublime," which here is understood as the rapture politicians get from building monuments to themselves and their causes (Baade and Matheson, chapter 13; van der Westhuizen, chapter 24). Megaprojects are manifest, garner attention, and lend an air of proactiveness to their promoters. Moreover, they are media magnets, which appeals to politicians who seem to enjoy few things better than the visibility they get from starting megaprojects; except maybe cutting the ribbon of one in the company of royals or presidents, who are likely to be present lured by the unique monumentality and historical import of many such projects. This is the type of public exposure that helps politicians get re-elected. They therefore actively seek it out.

Next there is the "economic sublime," which is the delight financiers, business people, and trade unions get from making lots of money and jobs off megaprojects. Given the enormous budgets for megaprojects there are ample funds to go around for all, including contractors, engineers, architects, consultants, construction and transportation workers, bankers, investors, landowners, lawyers, and developers. Finally, the "aesthetic sublime" is the pleasure designers and people who appreciate good design get from building, using, and looking at something very large that is also iconically beautiful, like San Francisco's Golden Gate bridge or Sydney's Opera House.

[Table 1 app. here]

All four sublimes are important drivers of the scale and frequency of megaprojects described above. Taken together they ensure that strong coalitions exist of stakeholders who benefit from megaprojects and who will therefore work for more such projects to happen.

For policy makers, investment in infrastructure megaprojects seems particularly coveted, because, if done right, such investment (i) creates and sustains employment, (ii) contains a large element of domestic inputs relative to imports, (iii) improves productivity and competitiveness by lowering producer costs, (iv) benefits consumers through higher-quality services and, finally, (v) improves the environment when infrastructures that are environmentally sound replace infrastructures that are not (Helm, 2008: 1; Clegg et al., chapter 11).

But there is a big "if" here, indicated above with the words "if done right." Only if this is disregarded – as it often is by promoters and decision makers for megaprojects – can megaprojects be seen as an effective way to deliver infrastructure. In fact, conventional megaproject delivery –

infrastructure and other – is highly problematic, with a dismal performance record in terms of actual costs and benefits, as we will see below. The following characteristics of megaprojects are typically overlooked or glossed over when the four sublimes are at play and the megaproject format is chosen for delivery of large-scale ventures:

1. Megaprojects are inherently risky due to long planning horizons and complex interfaces (Flyvbjerg, 2006; Davies, chapter 21).
2. Often projects are led by planners and managers without deep domain experience who keep changing throughout the long project cycles that apply to megaprojects, leaving leadership weak.
3. Decision making, planning, and management are typically multi-actor processes involving multiple stakeholders, public and private, with conflicting interests (van Wee and Priemus, chapter 6; Winch, chapter 15; Aaltonen and Kujala, 2010).
4. Technology and designs are often non-standard, leading to "uniqueness bias" amongst planners and managers, who tend to see their projects as singular, which impedes learning from other projects.[4]
5. Frequently there is overcommitment to a certain project concept at an early stage, resulting in “lock-in” or “capture,” leaving alternatives analysis weak or absent, and leading to escalated commitment in later stages. "Fail fast" does not apply; "fail slow" does (Drummond, chapter 9; Cantarelli et al., 2010; Ross and Staw, 1993).
6. Due to the large sums of money involved, principal-agent problems and rent-seeking behavior are widespread, as is optimism bias (Eisenhardt, 1989; Stiglitz, 1989; Flyvbjerg el al., 2009).
7. The project scope or ambition level will typically change significantly over time.
8. Delivery is a high-risk, stochastic activity, with overexposure to so-called "black swans," i.e., extreme events with massively negative outcomes (Taleb, 2010). Managers tend to ignore this, treating projects as if they exist largely in a deterministic Newtonian world of cause, effect, and control.
9. Statistical evidence shows that such complexity and unplanned events are often unaccounted for, leaving budget and time contingencies for projects inadequate.
10. As a consequence, misinformation about costs, schedules, benefits, and risks is the norm throughout project development and decision-making. The result is cost overruns, delays, and benefit shortfalls that undermine project viability during project delivery and operations.

In the next section, we will see just how big and frequent such cost overruns, delays, and benefit shortfalls are.

The Iron Law of Megaprojects

Performance data for megaprojects speak their own language. Nine out of ten such projects have cost overruns. Overruns of up to 50 percent in real terms are common, over 50 percent not uncommon. Cost overrun for London's Jubilee Line Underground extension was 80 percent in real terms. For Denver International Airport, 200 percent. Boston's Big Dig, 220 percent. The Canadian Firearms Registry, 590 percent. The Sydney Opera House, 1,400 percent. Overrun is a problem in private as well as public sector projects, and things are not improving; overruns have stayed high and constant for the 90-year period for which comparable data exist (Flyvbjerg, chapter 8; Hodge and Greve, chapter 16; Chung, chapter 23). Geography also does not seem to matter; all 104 countries and six continents for which data are available suffer from overrun. Similarly, large benefit shortfalls are common, again with no signs of improvements over time and geographies (Flyvbjerg et al., 2002, 2005).

Combine the large cost overruns and benefit shortfalls with the fact that business cases, cost-benefit analyses, and social and environmental impact assessments are typically at the core of planning and decision-making for megaprojects and we see that such analyses can generally not be trusted. For instance, for dams an average cost overrun of 96 percent combines with an average demand shortfall of 11 percent, and for rail projects an average cost overrun of 40 percent combines with an average demand shortfall of 34 percent. With errors and biases of such magnitude in the forecasts that form basis for business cases, cost–benefit analyses, and social and environmental impact assessments, such analyses will also, with a high degree of certainty, be strongly misleading. "Garbage in, garbage out," as the saying goes (Flyvbjerg 2009; for in-depth studies of dams, see Scudder, chapter 19 and Ahlers et al., chapter 25).

As a case in point, consider the Channel tunnel, the longest underwater rail tunnel in Europe, connecting the UK and France. This project was originally promoted as highly beneficial both economically and financially. At the initial public offering, Eurotunnel, the private owner of the tunnel, tempted investors by telling them that 10 percent "would be a reasonable allowance for the possible impact of unforeseen circumstances on construction costs."[5] In fact, capital costs went 80 percent over budget and financing costs 140 percent. Revenues started at a dismal 10 percent of those forecasted, eventually growing to half of the forecast. As a consequence the project has proved financially non-viable, with an internal rate of return on the investment that is negative, at minus 14.5 percent with a total loss to Britain of 17.8 billion US dollars. Thus the Channel tunnel has detracted from the British economy instead of adding to it. This is difficult to believe when you use the service, which is fast, convenient, and competitive compared with alternative modes of travel. But in fact each passenger is heavily subsidized. Not by the taxpayer, as is often the case for other megaprojects, but by the many private investors who lost billions when Eurotunnel went insolvent and was financially restructured. This drives home an important point: A megaproject may well be a technological success, but a financial failure, and many are. An economic and financial ex post evaluation of the Channel tunnel, which systematically compared actual with forecasted costs and benefits, concluded that "the British Economy would have been better off had the Tunnel never been constructed" (Anguera, 2006: 291). Other examples of financially non-viable megaprojects are Sydney's Lane Cove tunnel, the high-speed rail connections at Stockholm and Oslo airports, the Copenhagen metro, and Denmark's Great Belt tunnel, the second-longest under-water rail tunnel in Europe, after the Channel tunnel (see also Vickerman, chapter 17).

Large-scale ICT projects are even more risky. One in six such projects become a statistical outlier in terms of cost overrun with an average overrun for outliers of 200 percent in real terms. This is a 2,000 percent overincidence of outliers compared to normal and a 200 percent overincidence compared to large construction projects, which are also plagued by cost outliers (Flyvbjerg and Budzier, 2011). Given the central role of large-scale ICT projects in many change management projects in both government and business, the prevalence of ICT cost outliers are ticking time bombs under such projects, waiting to go off. Total project waste from failed and underperforming ICT projects for the United States alone has been estimated at 55 billion dollars annually by the Standish Group (2009).

Delays are a separate problem for megaprojects and delays cause both cost overruns and benefit shortfalls. For instance, results from a study undertaken at Oxford University, based on the largest database of its kind, shows that delays on dams are 45 percent on average (Ansar et al. 2014). Thus if a dam was planned to take 10 years to execute, from the decision to build until the dam became operational, then it actually took 14.5 years on average. Flyvbjerg et al. (2004) modeled the relationship between cost overrun and length of implementation phase based on a large data set for major construction projects. They found that on average a one-year delay or other extension of the implementation phase correlates with an increase in percentage cost overrun of 4.64 percent. To illustrate, for a project the size of London's 26 billion dollars Crossrail project, a one-year delay would cost 1.2 billion dollars extra, or 3.3 million dollars per day. The key lesson here is that in order to keep costs down, implementation phases should be kept short and delays small. This should not be seen as an excuse for fast-tracking projects, that is, rushing them through decision making for early construction start. All you do if you hit the ground running is fall, in the case of megaprojects. Front-end planning needs to be thorough before deciding whether to give the green light to a project or stopping it (Williams and Samset, 2010). You need to go slow at first (during project preparation) to run fast later (during delivery). But often the situation is the exact opposite. Front-end planning is rushed and deficient, bad projects are not stopped, implementation phases and delays are long, costs soar, and benefits and revenue realization recedes into the future and diminishes. For debt-financed projects this is a recipe for disaster, because project debt grows while there are no revenues to service interest payments, which are then added to the debt, etc. As a result, many projects end up in the so-called "debt trap" where a combination of escalating construction costs, delays, and increasing interest payments makes it impossible for project revenues to cover costs, rendering projects non-viable. That is what happened to the Channel tunnel and Sydney's Lane Cove tunnel, among many other projects.

This is not to say megaprojects do not exist that were built on budget and time and delivered the promised benefits (Gil, chapter 12; Davies et al., chapter 14). The Bilbao redevelopment project, with the Guggenheim Museum Bilbao, is an example of that rare breed of project (del Cerro Santamaria, chapter 22). Similarly, recent metro extensions in Madrid were built on time and to budget (Flyvbjerg, 2005) as were a number of industrial megaprojects (Merrow, 2011). It is particularly important to study such projects to understand the causes of success and test whether success may be replicated elsewhere. It is far easier, however, to produce long lists of projects that have failed in terms of cost overruns and benefit shortfalls than it is to produce lists of projects that have succeeded. To illustrate, as part of ongoing research on success in megaproject management the present author and his colleagues are trying to establish a sample of successful projects large enough to allow statistically valid answers. But so far they have failed. Why? Because success is so rare in megaproject management that at present it can be studied only as small-sample research, whereas failure may be studied with large, reliable samples of projects.

[Table 2 app. here]

Success in megaproject management is typically defined as projects delivering the promised benefits on budget and time. If, as the evidence indicates, approximately one out of ten megaprojects is on budget, one out of ten is on schedule, and one out of ten is on benefits, then approximately one in a thousand projects is a success, defined as on target for all three. Even if the numbers were wrong by a factor two – so that two, instead of one, out of ten projects were on target for cost, schedule, and benefits, respectively – the success rate would still be dismal, now eight in a thousand. This serves to illustrate what may be called the "iron law of megaprojects": *Over budget, over time, under benefits, over and over again* (Flyvbjerg, 2011). Best practice is an outlier, average practice a disaster in this interesting and very costly area of management.

The Megaprojects Paradox

The above analysis leaves us with a genuine paradox, the so-called "megaprojects paradox," first identified by Flyvbjerg et al. (2003: 1-10). On one side of the paradox, megaprojects as a delivery model for public and private ventures have never been more in demand, and the size and frequency of megaprojects have never been larger. On the other side, performance in megaproject management is strikingly poor and has not improved for the 90-year period for which comparable data are available, when measured in terms of cost overruns, schedule delays, and benefit shortfalls.

Today, megaproject planners and managers are stuck in this paradox because their main delivery method is what has been called the "break-fix model" for megaproject management.[6] Generally, megaproject managers – and their organizations – do not know how to deliver successful megaprojects, or do not have the incentives to do so. Therefore megaprojects tend to "break" sooner or later, for instance when reality catches up with optimistic, or manipulated, estimates of schedule, costs, or benefits; and delays, cost overruns, etc. follow. Projects are then often paused and reorganized – sometimes also refinanced – in an attempt to "fix" problems and deliver some version of the initially planned project with a semblance of success. Typically lock-in and escalation make it impossible to drop projects altogether, which is why megaprojects have been called the "Vietnams" of policy and management: "easy to begin and difficult and expensive to stop" (White, 2012; also Cantarelli el al., 2010; Ross and Staw, 1993, Drummond, 1998). The "fix" often takes place at great and unexpected cost to those stakeholders who were not in the know of what was going on and were unable to or lacked the foresight to pull out before the break.[7]

The break-fix model is wasteful and leads to a misallocation of resources, in both organizations and society, for the simple reason that under this model decisions to go ahead with projects are based on misinformation more than on information, with misinformation caused by a lack of realism at the outset. The degree of misinformation varies significantly from project to project, as seen by the large standard deviations that apply to cost overruns and benefit shortfalls documented by Flyvbjerg et al. (2002, 2005). We may therefore *not* assume, as is often done, that on average all projects are misrepresented by approximately the same degree and that, therefore, we are still building the best projects, even if they are not as good as they appear on paper. The truth is, we don't know, and often projects turn out to bring a net loss, instead of a gain, to the government or company that promoted them. The root cure to the break-fix model is to get projects right from the outset so they don't break, through proper front-end management, and then have competent teams deliver a realistic front end (Volden and Samset, chapter 18; Williams and Samset, 2010). But megaproject managers must also know how to fix projects once they break for the simple reason that so many break. The present book deals with both types of situation: (i) getting projects right from the start and (ii) fixing projects that break.

Challenges, Causes, Cures

The chapters in the book have been selected to give readers a thorough, research-based understanding of (i) the *challenges* in megaproject management, (ii) the root *causes* of those challenges, and (iii) *cures* that may help meet the challenges. The book is thus systematically focused on the *what*, the *why*, and the *how* of megaproject management. In addition, the book contains a set of case studies to exemplify general points.

First, as regards the *what* of megaproject management – the *challenges* – Lenfle and Loch (chapter 2) and Siemiatycki (chapter 3) present the historical overview. Ansar et al. (chapter 4) focus on the basic challenge of scale and attempt to theorize scale in terms of fragility. Levitt and Scott (chapter 5) deal with institutional challenges, especially as these pertain to global megaprojects, i.e., projects that span activities in multiple countries, as is increasingly common for megaprojects. van Wee and Priemus (chapter 6) spell out an important but often overlooked aspect of megaproject management, namely the ethical and political issues involved; what is megaproject ethics, they ask? Finally, Ren (chapter 7) poses a truly sobering question of current debt-financed megaproject investments in China: "Is this the biggest infrastructure bubble in the history of humankind?"

Second, for the *why* of megaproject management – the *causes* – Flyvbjerg (chapter 8) explores a recent claim made by Cass Sunstein, Harvard professor, that behavioral economics was pioneered by early research on large projects and that this research accounts well for behavior with megaproject planners and managers. Drummond (chapter 9) updates and appraises key theories on escalation of commitment and lock-in, as they pertain to megaprojects. Miller et al. (chapter 10) explain megaproject management in terms of games of innovation, and they explicate how the game is best played. Clegg et al. (chapter 11) give an overview of how scholars and practitioners make sense of megaprojects and megaproject management, and how power is related to such sensemaking. Gil (chapter 12) introduces a new collective-action perspective on the planning of megaprojects with a focus on dispute resolution, central to any megaproject. Baade and Matheson (chapter 13) spell out the drivers of megaevents in emerging economies, an issue of growing importance as megaevents and other types of megaprojects have shifted in increasing numbers from developed to emerging economies, with the major part of investments now happening in the latter.

Third, concerning the *how* of megaproject management – the *cures* – Davies et al. (chapter 14) describes a new delivery model for megaprojects aimed at securing innovation and flexibility in projects, and they illustrate how the model worked for three UK megaprojects. Winch (chapter 15), drawing on developments in strategic management research, broadens the notion of stakeholder management to better take into account pressing issues of future generations and the natural environment. Hodge and Greve (chapter 16) ask and answer the question of how well privatization works as a cure to the challenges of megaproject delivery. Vickerman (chapter 17) identifies as dubious the common claim that the wider benefits of megaprojects are large and will often justify projects, even when direct benefits do not. Volden and Samset (chapter 18) describe how Norway implemented a quality assurance program for megaprojects and how this has improved outcomes. Based on a lifetime of research, Scudder (chapter 19) closes this part of the book by synoptically asking and answering the following question of the perhaps ultimate megaproject, the megadam: "Does the good megadam exist, all things considered?"

Fourth, and finally, Holzmann et al. (chapter 20) kick off the *case studies* with an in-depth inquiry into how the team on Boeing's 787 cracked the code of innovation in megaproject delivery, something high on the agenda for most megaprojects, irrespective of type. Davies (chapter 21) spells out the lessons learned from the London 2012 Olympic Games in terms of systems integration, again a general concern in most megaprojects. del Cerro Santamaria (chapter 22) updates and sets straight the record for the perhaps most iconic urban megaproject of the past generation, the 1.5-billion-dollar Strategic Plan for the Revitalization of Metropolitan Bilbao, spearheaded by what Philip Johnson, the godfather of architecture, called "the greatest building of our time," Frank Gehry's Guggenheim Museum Bilbao. Chung (chapter 23) navigates the maze of Australia's slightly dodgy experience with public-private partnerships in the provision of motorways, and identifies the challenges and opportunities for going forward. van der Westhuizen (chapter 24) tells the story of megaprojects as mythical political symbols, focusing on Africa's first high-speed railway, the Gautrain, which was initially packaged with South Africa's bid to host the 2010 Soccer World Cup, another first for Africa. Lastly, Ahlers et al. (chapter 25) study the Aswan High Dam on the Nile and the Nam Theun 2 on the Mekong to illustrate how dam development has changed recently to a situation where political power is more diffuse and where basic transparency and citizens' rights are therefore more difficult to secure; the authors suggest "dam democracy" as an organizing principle for addressing these issues.

In sum, the chapters for the book were selected to be strong on theory and contain high-quality data, as an antidote to the weak theory and idiosyncratic data that characterize much scholarship in megaproject management (Flyvbjerg 2011). Strong theory is here understood as ideas with a high degree of explanatory power for phenomena in megaproject management. Good data are valid and reliable information that allows systematic comparison of important variables across projects, studies, geographies, and time, or make possible high-quality in-depth case studies. The focus on strong theory and good data is intended to help bring the field forward academically and professionally. As a further criterion, chapters were selected that are relevant not only to developed nations, but also to emerging economies, because at present the main part of investments in megaprojects is taking place here. Finally, chapters giving a historical overview of the field and good case studies have been included. The intention has been to produce a well-rounded book that is a must-read for anyone embarking on study, research, or practice in megaproject management, or who is impacted by megaprojects and wants to understand them better.

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Figure 1: Size of selected megaprojects, measured against GDP of selected countries.

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Table 1: The "Four Sublimes" that drive megaproject development.

Type of Sublime	**Characteristic**
Political	The rapture politicians get from building monuments to themselves and their causes, and from the visibility this generates with the public and media
Technological	The excitement engineers and technologists get in pushing the envelope for what is possible in "longest-tallest-fastest" type of projects
Economic	The delight business people and trade unions get from making lots of money and jobs off megaprojects, including for contractors, workers in construction and transportation, consultants, bankers, investors, landowners, lawyers, and developers
Aesthetic	The pleasure designers and people who love good design get from building and using something very large that is also iconic and beautiful, like the Golden Gate bridge

Table 2: Large-scale projects have a calamitous history of cost overrun.

Project	**Cost Overrun (%)**
Suez Canal, Egypt	1,900
Scottish Parliament Building, Scotland	1,600
Sydney Opera House, Australia	1,400
Montreal Summer Olympics, Canada	1,300
Concorde supersonic aeroplane, UK, France	1,100
Troy and Greenfield railroad, USA	900
Excalibur Smart Projectile, USA, Sweden	650
Canadian Firearms Registry, Canada	590
Lake Placid Winter Olympics, USA	560
Medicare transaction system, USA	560
National Health Service IT system, UK	550
Bank of Norway headquarters, Norway	440
Furka base tunnel, Switzerland	300
Verrazano Narrow bridge, USA	280
Boston's Big Dig artery/tunnel project, USA	220
Denver international airport, USA	200
Panama canal, Panama	200
Minneapolis Hiawatha light rail line, USA	190
Humber bridge, UK	180
Dublin Port tunnel, Ireland	160
Montreal metro Laval extension, Canada	160
Copenhagen metro, Denmark	150
Boston-New York-Washington railway, USA	130
Great Belt rail tunnel, Denmark	120
London Limehouse road tunnel, UK	110
Brooklyn bridge, USA	100
Shinkansen Joetsu high-speed rail line, Japan	100
Channel tunnel, UK, France	80
Karlsruhe-Bretten light rail, Germany	80
London Jubilee Line extension, UK	80
Bangkok metro, Thailand	70
Mexico City metroline, Mexico	60
High-speed Rail Line South, The Netherlands	60
Great Belt east bridge, Denmark	50

Notes

[1] See more at www.oxfordhandbooks.com.

[2] "Megaprojects" are usually measured in billions of dollars, "major projects" in hundreds of millions, and "projects" in millions or tens of millions. Megaprojects are sometimes also called "major programs."

[3] Google search January 18, 2016.

[4] "Uniqueness bias" is here defined as the tendency of planners and managers to see their projects as singular. This particular bias stems from the fact that new projects often use non-standard technologies and designs, leading managers to think their project is more different from other projects than it actually is. Uniqueness bias impedes managers' learning, because they think they have nothing to learn from other projects as their own project is unique. This lack of learning may explain why managers who see their projects as unique perform significantly worse than other managers (Budzier and Flyvbjerg 2013). Project managers who think their project is unique are therefore a liability for their project and organization. For megaprojects this would be a mega-liability.

[5] Quoted from "Under Water Over Budget," *The Economist*, 7 October 1989, 37–8.

[6] The author owes the term "break-fix model" to Dr. Patrick O'Connell, former Practitioner Director at the BT Centre for Major Programme Management, University of Oxford's Saïd Business School.

[7] For a rare look behind the scenes of a break-fix project – to see in real time how a break happens and a fix is attempted – see Flyvbjerg et al. (2014) about Hong Kong's XRL high-speed rail line to mainland China, which broke in 2014, midway through construction.