MAXIMIZING VALUE FROM LARGE-SCALE PROJECTS:

IMPLEMENTING FLEXIBILITY IN PUBLIC -- PRIVATE PARTNERSHIPS

Richard de Neufville, Engineering Systems Division, MIT

Stefan Scholtes, Judge Business School, University of Cambridge

Executive Summary

To extract maximum value from the development and delivery of major projects, project leaders need to deal proactively with a fundamental difficulty: the long-term future of these projects cannot be predicted accurately. Leaders can maximize value by making sure that their teams embed flexibility – otherwise known as real options -- into the design. This capability will enable the project managers to react to changing circumstances, taking advantage of opportunities and insuring themselves against downside risks.

To implement flexibility into the design and delivery of major projects, the partners leading the project need to influence each of four major processes that jointly determine its planning, design, and delivery.

- The specification of requirements has to recognize the possibility of various scenarios, rather than set forth a fixed set of requirements;
- The design team correspondingly should develop project schemes that permit multiple pathways of project evolution, according to the scenarios that develop;
- The appraisal process has to include suitable methods to capture the value of the options designed into the alternative project schemes;
- The implementation process has to recognize and facilitate choices between pathways and delivery.

Efforts focused on only one of these elements will be insufficient.

Context: Large-Scale Projects have Uncertain Outcomes

Large-scale, important projects – such as the preparation for the 2012 Olympics in Britain, the launch of the Airbus A380 New Large Aircraft, the development of oil fields, or infrastructure projects such as the Channel Tunnel – fundamentally differ from smaller, routine projects. They are not simply larger. Because they are large, however, these projects generally are

- More likely to be salient politically at the national or even international level, and thus sensitive to idiosyncratic changes in national priorities and public pressures (see Dartford box below);
- Subject to much greater uncertainties – not only politically, but also associated with market fluctuations, technological change, and the organizational complexity of the special purpose consortia set up to run the project – over their extended lifetime; and
- Likely to have significant impacts on the sponsoring organizations. Indeed, the main sponsors of any large project will have limited ability to spread the risks over many projects, and are more likely to be 'betting their company' or their reputations on the major project.

Dartford Crossing Bridge

In an early Private Finance Initiative (PFI), the UK Government contracted with a private Concessionaire to build a new bridge across the Thames as part of the London Orbital motorway. The Concessionaire was, at the price of assuming previous debt and funding the project, to be paid through the toll revenues for 20 years until 2008. In prospect, the Concessionaire took on considerable risk of losing money, much as the builders of the Channel Tunnel did. However, in this case the Concessionaire kept the costs low, the traffic was high, and the deal appeared to be immensely successful. At that point, popular sentiment became concerned about unfair profits. Thus in 2002 – 6 years early – the Secretary of State determined that the Government's financial commitments had been met and seized control of the enterprise.[1]

This is an example of the way politics can alter expectations, and transform business risks into games of "heads I win and tails you lose."

Leaders of large-scale important projects thus need to focus on the particular risks associated with such projects. They would not be wise to ignore these project risks along the lines that finance theory suggests to investors. They cannot spread their bets on project risks and focus narrowly on the market risks that cannot be avoided by diversification.[2] The leading organizations in a large-scale project need to recognize project risks directly in their planning, design and evaluation for the implementation of a major project.

To illustrate this point, consider the prospects of Private Finance Initiatives (PFI) for constructing hospital facilities in Britain. Health care is politically sensitive, and even relatively minor incidents can become front-page news and lead to political pressures and changes in regulations and other terms of contracts. In addition, medical technology is altering the delivery of health care and the design of hospitals substantially. As more surgical procedures are done on an out-patient basis, fewer hospital beds are needed for convalescence, and a greater percentage may need to be equipped for intensive, acute care. Specifications laid down in good faith today may easily appear misguided by the end of the PFI contract. Companies committing to the construction and operation of such projects are thus assuming substantial risks both to their reputations and their balance sheets.

Risks in large-scale projects are neither merely technical nor confined to the installation phase of the project. Indeed, the very notion of a project seems to be shifting in the context of PFIs and similar initiatives for very large-scale endeavors. A project is typically thought of as a set of well-defined activities that are carried out to create a product, an infrastructure system or a service. The project is finished when the system is successfully installed. This is not the case for most of today's large-scale projects. The notion of a project increasingly subsumes the commercial operation and success of the system as well. PFIs are often contracts with a 20-30 year revenue schedule, depending on commercial performance. Such long-term market uncertainties exacerbate the complexities and technical uncertainties of building the system. London's Millennium Dome is a good example of a project that was successful as a technical installation project but is likely to be unsuccessful from a full economic cycle view. Another example in point is the Iridium Satellite phone service (see Iridium box below). Commercial failure hurts the income and reputation of the parties involved in such large-scale projects just as much as technical failure.

Leaders of large-scale, important projects thus have a special obligation, to themselves, their organizations, and their clients, to manage effectively the special uncertainties that they confront.

Using Project Flexibility to Deal with Uncertainties

Effective leaders will use project flexibility as an important means to deal proactively with the inevitable uncertainties associated with large-scale projects. As in playing chess, the best participants will develop plans that incorporate the ability to respond to a variety of developments.

Only poor players define a plan and stick to it, impervious to evolution of the situation on the board.

Major forms of project flexibility are designed to deal with downside risks. These allow the participants to minimize their exposure to losses and otherwise avoid unpleasant outcomes. These can be seen as some form of insurance, obtained by the way the project is designed. For example, developers for a major hospital complex – slated at the start to provide 1000 beds, say – might propose to deliver the facility in 500-bed increments, as a way of giving themselves and their clients the opportunity to see how the needs for the number and type of beds will develop. This approach might enable them to avoid the construction of facilities that might prove to be unnecessary or otherwise inappropriate to the demands at the time of implementation. BP's development of the Andrew platform in the North Sea is a good example of how project leaders can embed flexibility in a project to provide insurance against downside risks (see box)

The Andrew Platform in the North Sea

The development of the Andrew platform faced a substantial technological uncertainty: would the water pressure in the aquifer be sufficient to force the oil out, or would an extensive pumping system have to be implemented? The project designed without a pumping system appeared too risky financially, due to the high cost of retro-fitting pumping if required. On the other hand, the project designed with pumping did not offer sufficient return.

The BP designers created an acceptable – and ultimately successful -- project by designing the platform with the pipes necessary for a pumping system, but without the pumps and the rest of the topside gear that would be required. This investment significantly reduced the cost of providing the full pumping system if that were needed, but its modest cost did not affect the financially viability of the project. In effect, this investment in flexibility insured the Andrew Platform against the financial risk of having to retro-fit an entire pumping system.[3]

Uncertainties can also represent opportunities. A project may well prove to be unexpectedly beneficial, profitable or otherwise desirable. In such cases, project leaders will want to capitalize on success by extending or augmenting it in ways they had not originally planned to do. However, if they have not made appropriate provision for this possibility, they may not be able to take advantage of these upside opportunities as quickly and cost-efficiently as desired. The US development of its original Geographical Positioning System (GPS) provides a case in point. The American Armed Forces developed this system for strictly military purposes. Once they launched the enabling constellation of satellites, however, everyone else could use these "lighthouses in the sky" and locate themselves and others anywhere in the world. The commercial applications have proven to be enormously valuable. However, US Government was unable to capitalize on this commercial success, or to recoup any of its investment in this system, because it did not provide any means to charge for access to its signal. In this case, the project developers failed to provide the flexibility to adapt to beneficial opportunities, and thus failed to take full advantage of the project. Designers with foresight, however, will think through the scenarios of success, and enable their systems to adapt and exploit possible beneficial developments. The Portuguese designers of the Tagus Bridge at Lisbon are a good example (see box).

Tagus River Bridge

The first bridge across the Tagus at Lisbon was designed for highway traffic. The Government at the time insisted that its structure be strong enough to carry rail traffic, even though there were then no plans for any form of commuter railway system. About 20 years later on, once Portugal had joined the European Union and received funds to develop a mass transit network in the capital, it was able to exploit this capability and extend the service throughout metropolitan Lisbon.

This investment in extra strength for the bridge endowed the project with the flexibility to adapt to new circumstances. It enabled Portugal to take full advantage of the upside opportunity when it materialized. In effect, it provided the project with a "call" option built into the physical project.[4]

In general, the best leaders of important projects will

- Recognize that the outcomes of their projects are uncertain. Their results and performance cannot be predicted exactly. On the contrary, they can be expected to fall over a wide range, from failure to great success. This range should be anticipated and dealt with proactively.
- Impel the design teams to develop flexible project schemes, those that will enable managers to adapt the projects to the circumstances that develop. They may usefully consider these flexibilities to provide some combination of insurance and openness to exploit new opportunities.
- Concurrently, make sure that their appraisal processes properly assess the value of these flexibilities, to insure that the associated investments are appropriate – neither too large to sink the project, nor too small to provide inadequate provision for the future.
- Implement a dynamic project delivery process, which takes explicit account of efficient use of the flexibility incorporated into the system.

The sum of the process is that good project leaders will recognize the distribution of outcomes for a project; alter it in their favor by arranging to minimize their exposure to bad outcomes, and to maximize their opportunities to make the most of good openings; and to judge the level of flexibility on solid analytic grounds.

A New Appraisal Framework is Needed

A word of caution is required here. Conventional methods of project appraisal are not suitable for evaluating projects with flexibility. To account properly for the value of flexibility in design, leaders of major projects need to adjust their methods of project evaluation.

Flexibility in a project is like a switch. The capacity to adapt to new circumstances – to add rail service to the Tagus Bridge for instance – can be left dormant or “off” until management determines that it is desirable to be used, or turned “on”.[5] There can thus be alternative possible benefits of a single project, depending on whether a flexibility “switch” is “on” or “off”. This characteristic of flexible projects makes conventional methods of project appraisal inadequate.

Conventional methods of project analysis – such as return on investment, discounted cash flow, or net present value – all assume that a known cash flow or benefit stream is associated with a project. Except in simple situations, this is simply not realistic however. Because of the switching feature, the assumption of a single cash flow is certainly not true for projects that are flexible. In general, the assumption is untenable whenever project managers have the capacity to react to circumstances and make management decisions that can significantly alter the performance of a project – which is nearly always! In short, the appraisal process for major projects needs some form of adjustment.

The choice of the appropriate method for evaluating project flexibility depends on the situation. There is no simple solution. Calculations of the value of flexibility have to account for different types and levels of switches, and the circumstances or scenarios in which they would be flipped. A proper valuation requires expert, experienced guidance. Moreover, there is no single solution. The textbook, theoretically correct methods often are not practical because the data they need do not exist, or the practical situation does not correspond to the theoretical case. Alternative procedures may be satisfactory in some cases, but too simplistic in others.

The points senior project leaders need to retain are just these:

- Conventional techniques of project appraisal are not suitable for assessing the value of project flexibility, and
- No single approach is valid for all kinds of projects.

Flexibility delivers "All gain, for no pain"

Leaders of major projects should also recognize that flexibility is a particularly attractive type of asset. Once you have it, it only provides gain. More precisely, in some future scenarios the flexibility will be worthless; because it is not exercised (the switch is not used). In others, the cases when the switch is used, flexibility can take on significant value, when the system is adapted to new circumstances. It is in this sense that flexibility, once installed, is "all gain, for no pain".

This feature is sometimes usefully thought of as the "hockey stick" diagram shown below. Value is flat over a range of scenarios when flexibility is not used, and then ramps up rapidly when useful. This broken line description of the value of the flexibility is what gives particular value. This is known as the asymmetry of the outcomes from flexibility. The hypothetical case of the El Dorado mine explains the phenomenon (see box).

El Dorado Mine

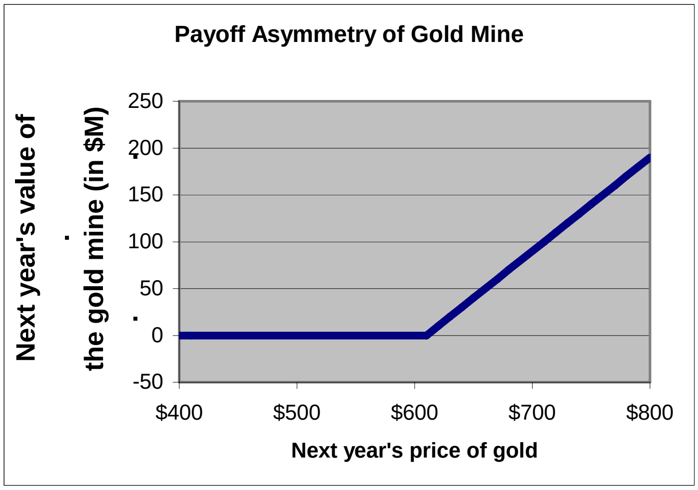
As part of a merger, your company suddenly owns a two year lease on a gold mine. Equipment is being installed and will be operational next year. You will be able to extract gold for $610/oz.

Unfortunately, the price of gold is now $580/oz and is likely to stay in that range. But next year's price is uncertain: it could be anywhere between $400/oz and $800/oz. Is the mine worthwhile?

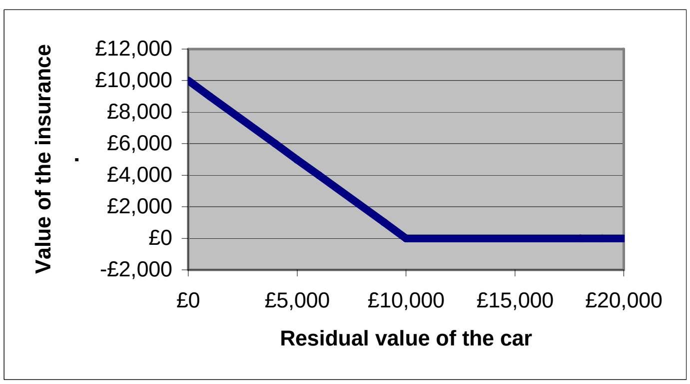
A simplistic analysis tells you NO – you can't lock in a gold price above the cost of extraction.

A more detailed analysis, however, provides gives the hockey stick picture. If the gold price remains below $610/oz, the mine is indeed worth nothing. You would not excavate and have no extra costs. If, however, the gold price exceeds $610/oz then you would excavate and make profits – as much as $190/oz if the gold price hits $800/oz. This asymmetry results from your flexibility to excavate or not, depending on the price of gold next year.

Hockey-stick payoff profiles are characteristic of options. Clearly the mine has value – but it is not visible if your appraisal process focuses on the most likely value and does not allow for scenarios.



The same hockey stick principle applies to downside scenarios. Consider the flexibility offered by an insurance policy. Suppose you insure your car for up to its full value of £10,000. If you have an accident, the value of the policy equals the damage, whatever that may be. If you have no accident, and thus do not flip the switch and cash in your policy, the policy has no value. The overall value of the policy is then as indicated in the figure below – a hockey stick in the direction of the negative scenarios.



Flexibility can have a complex payoff profile, depending on the scenarios in which it is exercised. However, the two hockey sticks above are most common and will often serve as the building blocks for more complex profiles. The gold-mine hockey stick exploits upside scenarios, the insurance hockey stick exploits downsides.

Flexibility is Most Valuable when Uncertainty is Highest.

Leaders of major projects should be aware that flexibility is especially valuable for the most uncertain projects. It is thus especially valuable for major, unique, and long-term investments – where the future prospects are most difficult to predict. To get an intuitive feeling of why this is so, think about insurance. If there is no risk of any mishap, an insurance policy is worthless. The greater the risk, the more likely you are to get sick or have an accident, the more the policy is worth.

Flexibility thus differs from other classes of assets. Indeed, the general rule is, the greater the risk, the less something is worth. The situation is just the opposite for flexibility assets. This particular feature is due to the hockey-stick value of flexibility. Because the value of the flexibility is either zero or something, the positive values are not cancelled out by the zero values. Events that are farthest from the trend, give the highest value. A second look at the El Dorado mine shows how this works out (see box)

El Dorado increases in Value the more Gold Prices Vary

To understand why the value of the flexibility to excavate increases the more the price of gold varies; assume for simplicity that the gold price can have one of two values. Imagine that God flips a coin. The gold price is then either \$600+ X if the coin shows head, or \$600-X if the coin shows tails. The size of X determines the level of uncertainty in the gold price; the higher X, the less certain we are about the gold price. (X is sometimes referred to as the “volatility”)

Consider the effect of the level of uncertainty, X on the value of the gold mine. If it is below \$10/oz, then we will not excavate because the gold price will not exceed the excavation cost of \$610/oz. If X exceeds \$10/oz, then it is worth excavating in the upside scenario and we gain \$X-10 for each ounce of gold excavated. This value grows with the uncertainty level X.

The downside price of gold, \$600-X, on the other hand, will not reduce the value of the mine below zero. No matter how low \$600-X is, it is never worthwhile excavating. The possible low prices for gold will thus not counterbalance the possible high prices. The greater the X, the riskier the project, the more the flexibility to excavate is worth.[6]

Flexibility and Financial Options

Flexibility in a project is an asset similar to options in the financial market-place. Flexibility in a project is often referred to as a "real option". This section sketches out the links between flexibility in a project and options in finance. However, these links are mostly conceptual. It is difficult in practice to apply the procedures of financial analysis to an appraisal of the value of flexibility to project planning, design, and implementation.

Options are common-place in the world of finance, where they can be thought of as bets on stock prices. A financial option gives its owner the right but not the obligation to buy ("call" option) or sell ("put" option) a stock for a fixed price (the "strike price") at a fixed point in time ("European" option) or over a fixed period ("American" option). You will not exercise a call option on BT stock for £2.75 if the BT stock price is £2.50 – you can buy the stock cheaper in the market than by exercising your call option. Finance people say the option is "out of the money". However, if BT trades at £3.00, then you can buy the stock for £2.75, sell it immediately for £3.00 and cash in the difference of £0.25 – this is called an "in the money" option. Call options are therefore worth more if the stock price goes up. They have the same payoff profile as the gold mine.

In contrast, if you own a put option for BT stock for £2.75, then you can sell the stock for £2.75. If BT trades at £2.50 then you can buy a share on the market, sell it for £2.75 by exercising your put option, and pocket the difference of £0.25. You wouldn't exercise your put option if BT trades above £2.75 – the option would be out of the money. A put option therefore has more value the lower the stock price is. For the owner of a BT share, a put option acts as an insurance, just as the car insurance above. The payoff profile has the same shape as the insurance profile.

For persons familiar with financial options, it can be helpful to think of flexibilities in design either as put options that shelter the project from downside risks, or as call options that enable project leaders to capitalize on upside opportunities. These calls and puts are the two sides of the flexibility coin.

Implementing Flexibility for Large-Scale Projects

How can leaders implement flexibility in large-scale projects? How can they increase the expected value of the projects that their organizations plan, design, and deliver? The short answer is that they need to get several distinct parts of their organization to change their traditional practice. Leaders need to revise the "marching orders" they give to their planners, designers, economic analysts, and operational managers. Specifically, leaders need to make sure their teams fully recognize the long-term uncertainties associated with major projects and act in consequence.

To appreciate what is required to implement flexibility into the design and delivery of major projects, it is useful to recognize how organizations currently plan and implement these ventures. This sketch highlights the changes needed.

<u>Base Case: Current Process for Design and Delivery of Major Projects</u>[7]

In general, the development of projects passes through four salient processes. In different organizations, these activities will have various names, but the overall process is necessarily similar. As summarized in the subsequent table, these processes are those of:

- *Definition of Requirements*: One or more teams prepare forecasts and then a set of requirements for the design of the project. For example, specialized economists might develop models to predict the demand for transport services in a given plan year, and another group would translate the results into specifications for the project. The net result of these coordinated activities is a set of requirements that the design team must meet.
- *Design of Project:* Design experts develop plans to meet the requirements. To the extent possible, they will "optimize" the configuration to minimize cost or to maximize value. In doing so, they will anticipate the economic arguments of the subsequent appraisal team; so that their eventual proposed design finds favor.
- *Project Appraisal:* Evaluation experts, typically economists, will calculate the value of proposed designs. This process both provides a check on the designers, to protect the organization from overly ambitious design schemes, and ranks projects in order of priority. Its analysis normally uses single best estimates of cost and value, and applies techniques suitable to those fixed quantities, such as discounted cash flow analysis. For example, major resource companies instruct their teams that all appraisals be done on the basis of a common, assumed price for their product.[8]
- *Implementation:* Construction or manufacturing groups build and operate the system as near as possible according to plan.

Current Processes in the Design and Delivery of Large-Scale Projects

Process	Product of this Process
Definition of Requirements	**Specifications that Design must meet**
Design of Project	**A best Design**
Project Appraisal	**The value of Project**
Implementation	**Delivery of Project according to plan**

Overall, these activities first define a fixed set of requirements, the design team then creates the "best" plan to meet that need, the appraisal vets this plan according to the stated requirements, and the implementation process delivers the product. The $4 billion development of the Iridium satellite phone service illustrates how this proceeds – and suggests how it fails (see box).

Iridium Satellite Phone Service[9]

The deployment of the Iridium satellite phone service was an immense technological achievement. Within about a decade, a consortium led by Motorola designed, fabricated and launched a constellation of satellites to provide phone service from and to any part of the world.

The delivery process first defined the requirements for the system, in terms of various measures of capacity and service; the design team then configured the satellites and constellation that met these requirements at minimum cost; this design was then green-lighted by the business planning unit; and the Iridium consortium delivered the system as planned.

Unfortunately, the $4 billion project was a financial disaster. Less than 100,000 customers originally signed up instead of millions anticipated by the requirements. The system went bankrupt and was sold for around $25 million, that is, for about ½ percent of the investment.

Why was Iridium such a failure? Fundamentally, because the process hinged on a fixed specification of the demand and the requirements of the system. This in turn constrained the designs to a fixed plan. The appraisal correspondingly focused on the requirements and did not face up to the economic risks.

To avoid such failures, each of the processes needs to recognize the major uncertainties associated with the project. Fixing adjusting one process alone will not be sufficient.

Proposed Process for Design and Delivery of Major Projects

To get the most out of large-scale projects, it is necessary to make sure that each element recognize the major uncertainties associated with the project, and deal with them proactively. This requires leadership and direction. Project leaders need to direct the several parts of their organization appropriately. Here are some suggested “marching orders” for each of the processes in the planning, design and delivery of major projects:

- *Definition of “Requirements”:* In addition to identifying a most plausible forecast of needs and requirements, expand the process to identify alternative scenarios of needs, and identify the requirements suitable for each of these situations. These ranges of possible “requirements” define a range of conditions that the designers should be able to satisfy.
- *Design of Project:* Your task is now to develop an initial design that can be adapted to the scenarios that actually occur. In short, you now need to develop contingency plans. The complete plan should specify under what conditions the adaptations would occur, and how the adaptation would take place.
- *Project Appraisal:* The project appraisal process now needs to value the designs and their associated flexibilities. Some form of “options analysis” is needed, since the usual analysis of known cash flows is not adequate when a project can be adapted in many ways.
- *Implementation:* Your task is to implement the initial plan and to execute the contingency plans as appropriate. To do this, you need to augment your traditional activities in two ways. You should establish a suitable monitoring process that tracks the situation so that you will be aware of changes and be able to carry out the contingency plan. You should regularly review these data, to determine whether the time is ripe for the built-in flexibility to be exercised.

These marching orders for the recognition of project uncertainties, and for dealing effectively with these risks by incorporating needed flexibility to adapt, should lead each of the elements of the planning, design and delivery process to produce new products, as the table below indicates. The example of the toll road project illustrates how this might work out.

Proposed Processes in the Design and Delivery of Large-Scale Projects

Process	New Products of this Process
Definition of Requirements	**A range of forecasts or scenarios, and corresponding possible needs**
Design of Project	**An initial design that can adapt flexibly to scenario and needs that develop**
Project Appraisal	**Appraisal of the project including the option value of the design flexibility**
Implementation	**Monitoring of conditions and adapting the initial design as fits the actual scenario**

Toll Road Project

The project is to deliver a toll road over the next 20 years, that is, to provide sufficient service at reasonable cost over this period. The project is not simply to build it in a single phase. Properly conceived, the project involves an initial construction and additional improvements as and when needed.

The forecast should include not only high and low ranges of traffic (maybe the region will grow faster, or maybe fuel prices will constrain traffic), but also alternate scenarios for where exits and interchanges might be desirable.

The design might propose a 4-lane motorway, with sufficient right-of-way and span of the crossing flyovers, to permit widening the toll road to 6 lanes, or incorporating reversible or special purpose lanes. Also, the design might land-bank space for extra exits.

The appraisal process would evaluate the different kinds of flexibilities proposed by the design, recognizing the uncertainties and multiple possible cash flows, accepting some of the proposed flexibilities and rejecting others.

The implementation would monitor traffic flows and levels of congestion, and incorporate these data into periodic reviews to determine if the time had come to add lanes or otherwise take advantage of the flexibilities built into the original design.

Acknowledgements

This briefing paper has benefited from the perspectives of our colleagues who have focused on the management of complex projects, notably Donald Lessard[10] at MIT and Arnoud DeMeyer[11] currently at INSEAD and soon to be at the Judge Business School at the University of Cambridge.

Footnotes

[1] See UK Highways Agency, "Dartford-Thurrock Crossing Road User Charge 2004-2005 Account," http://www.highways.gov.uk/roads/projects/8606.aspx

[2] Finance theory may well apply to the financial sponsors in a consortium, but neither to the companies that carry out the project and put their brand at stake, nor to the Government departments involved.

[3] Description provided by Dr. Colin McGill, BP, Sunbury, UK.

[4] Civil Engineering, Oct 1998, http://www.pubs.asce.org/ceonline/1098feat.html . Similarly, the George Washington Bridge between Manhattan and New Jersey, first opened in 1931, was originally designed to be strong enough to carry a second deck of traffic, which was added in 1962.

[5] The switch analogy is useful, but should not be pushed too far. For example, the flexibility to expand a project may allow for several different levels of new capacity, not just one. The analogy is sufficient, however, for the point being made here.

[6] A word of caution is in order at this point. The value of flexibility benefits from increased uncertainty of the gold price, the uncertainty that is observed before the flexibility is used. It will not benefit from increased uncertainty in variables that are not related to its use, for example the amount of gold in the mine, which might only be known after excavation.

[7] This discussion generally follows the standard prescriptions in Systems Engineering texts, such as that of Sage, A. P. (2006) *Systems Engineering*, John Wiley and Sons, Hoboken, NJ.

[8] This process is standard for major oil companies such as BP and Shell, and for mining companies such as Codelco, the National Copper Company of Chile.

[9] See de Weck, O. et al, Staged Deployment of Communication Satellite Constellation in Low Earth Orbit, Journal of Aerospace Computing, Information, and Communications, Vol. 1, No. 3, Mar. 2004, pp. 119-131, http://ardent.mit.edu/real_options/

[10] Miller, R. and Lessard, D. (2000) *The Strategic Management of Large Engineering Projects,* MIT Press, Cambridge, MA.

[11] Loch, C., DeMeyer, A., and Pich, M. (2006) *Managing the Unknown: a New Approach to Managing High Uncertainty and Risk in Projects,* John Wiley and Sons, Hoboken, NJ.