

Oil and Gas Industry Megaprojects: Our Recent Track Record

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Summary

In a recent major study of industrial megaprojects, the author finds that oil and gas industry megaprojects fared very poorly. Earlier studies showed that the results of oil and gas megaprojects were quite similar to the results from megaprojects in other industrial sectors. With this much larger and more recent set of megaprojects, we find that upstream megaprojects are more fragile than their non-oil and gas industry cousins. The author attributes this finding to the poor functional integration that characterizes upstream project organizations, which makes these complex projects much more sensitive to poor preparation, schedule aggressiveness, and loss of continuity in project leadership.

Introduction

Projects throughout the process industries—oil and gas, chemicals, and minerals—have become significantly larger and more complex over the past decade or so. The underlying reasons for increasing project size and difficulty are understood—we are developing natural resources in progressively more difficult circumstances simply because we have to. Moreover, the choice of oil and gas developments is influenced by the decisions of some large resource-holding countries to restrict or delay the development of some more easily accessible reservoirs.

Eight years ago at the Offshore Technology Conference, the author reported on a distressing pattern that Independent Project Analysis (IPA) was seeing in offshore projects: Success, measured by how well we meet promises made at the time of the financial investment decision (FID), declines rapidly with project size (Merrow 2003). (Note: IPA benchmarks projects before FID and project systems in the oil and gas and other capital-intensive industrial sectors.) While projects in the USD 300- to USD 600-million range were largely successful, the success rate for the megaprojects—defined as exceeding USD 1 billion measured in constant start-of-2003 terms—was approximately 50%. Interestingly, megaprojects in other industrial sectors, such as downstream oil and gas, minerals, and chemicals, had approximately the same rates of success and failure.

In this updated analysis with a much larger sample of both oil and gas and other process industry megaprojects, our conclusion is quite different for oil and gas projects. While non-oil and gas development projects increased in size and difficulty, they maintained a success rate of approximately 50%. This rate of success is certainly not good, but at least it had not declined despite the much more difficult projects market. Meanwhile, the performance of oil and gas megaprojects collapsed; only 22% of these projects could reasonably be called successful. While the successful projects were spectacularly successful, the other 78% were equally unimpressive

with 33% real cost overruns, cost indices* that averaged 1.37, and execution schedule slip of 30%. More importantly, a disappointing 64% of these projects experienced serious and enduring production attainment problems in the first 2 years after first oil or gas.** The issue this paper addresses is why the relative performance of oil and gas megaprojects dropped so precipitously in the first decade of the twenty-first century.

Database and Methodology

For the larger study of which this paper is a small part (Merrow 2011), the author employed detailed project information from three IPA databases:

The Onshore Processing Facilities database, which contains data for minerals, petroleum processing† and refining/upgrading, and chemicals megaprojects.

• The Offshore Oil and Gas Production database, which includes information on the facilities and wells programs for offshore reservoirs.

• The Onshore Upstream database, which contains the equivalent information for onshore field developments.

Because so many megaprojects have been completed during the past decade, the resulting database is much more robust than the database used to support IPA's earlier studies. The average project in the database is approximately USD 3 billion measured in start-of-2009 terms. The largest project, a large field development, was USD 18 billion. The median authorization date is 2003. The composition of the database is described in **Table 1**.

Oil and gas production projects dominate the sample, followed by petroleum processing facilities of one kind or another (refinery projects, heavy oil upgraders, and standalone gas plant projects) and minerals mining and processing complexes. All other types of projects constitute less than a quarter of the sample. The oil and gas projects were executed by 33 companies acting as lead operator. Those operators were almost evenly divided among large integrated international oil companies, national companies, and the so-called independents.

The projects are distributed around the world in many of the major producing provinces. **Table 2** shows the worldwide distribution of the projects.

Methods

To help understand the patterns in the data, a number of very standard statistical techniques are employed, including ordinary least-squares regression, logit and probit regression, and frequency tables tested with Pearson's chi-square for statistical significance. We report statistical significance using the conventions shown in **Table 3**. ["Statistical significance" indicates that a result is unlikely to have been generated very often if repeated draws of random data

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*The IPA cost index measures the competitiveness of facilities cost relative to industry norms for like developments.

**Production attainment is the ratio of actual oil and gas production to forecast of production levels made at FID. It is the largest single driver of return on investment.

†The term petroleum processing refers to standalone gas and oil processing facilities that are not an integral part of a new reservoir development.

<u>Industrial Sector</u>	<u>Number</u>	<u>Percent of Sample</u>
Oil and gas production	130	41
Petroleum processing and refining	66	21
Minerals and metals	47	15
Chemicals	31	10
Liquefied natural gas (LNG)	24	8
Power generation	8	3
Pipelines	7	2
Other	5	2
Totals	318	100*

*Does not add because of round-off error.

<u>Upstream Project Location</u>	<u>Percent of Sample</u>
Europe	23
South America	16
West Africa	14
United States	11
Middle East/North Africa	10
Central Asia	8
Australia	8
Asia	7
Canada	3
Total	100

had been made. As a matter of convention, IPA generally uses a 5% chance, but most of the results discussed in this paper are much stronger than that threshold. The statistical significance is indicated by $Pr < .XX$, which means the probability is less than the number (XX) shown.] Unless otherwise noted, only results that are statistically significant at a .05 probability or less are reported. Two-tailed tests are also employed.

Sample Bias

There are two known biases in the data, both of which will tend to make the upstream project results look better than a fully random sample of upstream megaprojects might.

- Europe is overrepresented, which provides a bit of *positive* bias to the sample. E&P megaprojects in the North Sea, Atlantic margin, and onshore were approximately twice as likely to be successful as projects generally. Even then, they failed more often than non-E&P megaprojects.

- At IPA, we know for a fact that our clients are less likely to provide us the opportunity to collect final data for disaster projects than for normal projects. A variety of reasons is put forward, ranging from the termination of involved personnel to pending litigation to a lack of knowledge of the actual costs. As a result, some very poor projects escape the benchmarking process, which biases the sample.

Because the direction of the biases is understood and reinforces rather than undermines our conclusions, the presence of the biases is not a major concern.

Oil and Gas Outcomes Are Poorer

As stated in the Introduction, upstream megaprojects are not faring as well as other industrial megaprojects. **Table 4** provides some evidence of this.

When a project suffers a major deviation from its FID promises, it is classified as a failure. This does not necessarily mean that the project was unprofitable; rather, it means that the net present value (NPV) of the project was much lower—generally less than half—than it would have been if the project had delivered on its FID promises. Using the criteria for success and failure laid out in Merrow (2011), only 22% of oil and gas projects were successful versus half of non-E&P projects ($Pr > |z| < .001$).

As seen in Table 4, the typical oil and gas megaproject was very expensive, and a great deal more expensive than planned. It was also nearly a year late. Worst of all, it was frequently quite disappointing in terms of production. The failure to produce is by far the most economically damaging result.

When we separate the small group of successful E&P megaprojects, a much clearer picture emerges of the size of the economic disaster represented in the overall results. **Fig. 1** shows the difference between the successful oil and gas megaprojects and the failures. The 22% of E&P megaprojects that succeeded were truly brilliant projects: Their average cost was lower than budgeted and they were on time, they were very cost effective, they had average schedules, and they all produced as promised. The successes were as challenging technologically as the failures—there is no systematic difference in water depth, metocean conditions, or technical complexity. In fact, the successes were, on average, *more* innovative than the failures, although the difference is not statistically significant.

By contrast, the failures were dismal projects: They were badly overrun, very expensive, and very late in delivery, and two-thirds of them were production failures. The reader with good pattern recognition skills, however, will have noted the anomaly in Fig. 1: the schedule indices. Even though the failures slipped by 30%, their required execution time was just a few percent longer than that of the successes. Conversely, the successes were extraordinarily successful in every outcome dimension except schedule, in which they were merely average. That anomaly in the pattern allows us to begin to understand what separates successful and unsuccessful upstream megaprojects: whether or not the projects set aggressive schedules.

We have now established that upstream megaprojects fail more often than non-upstream megaprojects. We have established that the successes were very good projects indeed and that the failures were very disappointing, except regarding schedule, in which they were about average. Now, we explore the reasons for these results.

Understanding the Poorer Outcomes

There are three major factors that, taken together, explain the poorer outcomes of upstream megaprojects. All three are manifestations of the industry's struggle to effectively integrate the functions that are needed to produce excellent upstream projects. The three factors are:

- Front-End loading (FEL) is much more important for oil and gas megaprojects. FEL is the owner work process that prepares a

Technique	Test Statistic	Notation
Least squares or t-test	t-ratios/t-test	$Pr> t <.0X$
Logit or probit regression	z-ratio	$Pr> z <.0X$
Pearson correlation	r	$Pr> r <.0X$
Cross tabulation	Chi-square (χ^2)	$Pr> \chi^2 <.0X$

Measure of Merit	Upstream Megaprojects	Other Megaprojects
Cost overrun (%) [*]	25	15
Cost competitiveness % of industry average capex ^{**}	127	1.11
Slip in execution schedules (%) [†]	22	15
Severe and continuing production shortfalls ^{††}	45	32

^{*} Cost overruns are measured as the final actual capital cost, including Phase 1 well construction, divided by the FID estimate, with both adjusted to the same currency and time base (escalation removed).

^{**} Competitiveness is measured as the relationship between project cost per unit of capacity vs. industry average cost, with all adjusted to the same currency and time base.

[†] Slip is measured as the actual time from FID to first production divided by the time promised at FID.

^{††} A project is considered a production attainment failure if the project suffers extended shut-ins of production into the second year after first oil. E&P projects in this category averaged less than 50% of first-year planned production, even after adjusting for slips in execution schedule.

project for FID. FEL is usually formatted into three stages: business case development and appraisal, scope development, and front-end engineering design (FEED), which also includes execution planning.

- Continuity of the project leadership is almost essential to project success and much more important for oil and gas projects than for those from other industrial sectors.

- The strong tendency of upstream businesses to establish aggressive schedules is different from non-upstream asset developments, and exacerbates and accentuates the effects of the two previously described factors.

We will discuss each factor in turn, showing the data that support the conclusions.

FEL

For new field development projects, FEL includes the appraisal and definition of the reservoir, definition of the facilities, and definition of the well construction program. There are entirely analogous processes in other industrial areas. IPA measures FEL on a numerical index that runs from 3.00, which is the best possible, to 12.00, which indicates that no work has been done at all.* We divide the scale into descriptive categories as shown on the abscissa of Fig. 2. All projects and all outcome areas of projects are responsive to the completeness of FEL.

As shown in Fig. 2, however, oil and gas megaproject outcomes are particularly sensitive to the completeness of the front-end work. As FEL degrades, megaproject cost overruns mount quickly.* The average oil and gas megaproject was defined to a level in the middle of the *Fair* range. The typical non-upstream megaproject was defined in the upper half of the *Good* range. Given the difference in the slopes of the regression lines, that difference translates into significantly more cost growth for oil and gas projects.

*IPA's approach to measuring front-end definition of projects has been described in a number of prior publications and need not be repeated here. See Andrew F. Griffith, "Improving Project System Performance Through Benchmarking," Proceedings of the PMI Global Congress 2006, Madrid, Spain and Andrew F. Griffith and Mary Ellen Yarossi, "Stage-Gated Process for Project Definition of Capital Projects," 19th IPMA World Congress, New Delhi, India, 13–16 November 2005.

The Effects of Turnover in Project Leadership

Like poor FEL, turnover in the leadership positions, especially the project director position, damages project outcomes. This has been established quantitatively for many years. For smaller projects, turnover in the project-manager position usually drives a delay in execution and a modest amount of cost growth** because minor changes to the project scope are made by the functions that were not getting all they wanted from the prior project manager.

For megaprojects, the turnover of the project director is associated with substantially poorer project outcomes. Some, but only some, of the association is created by decisions to replace the project directors of failing projects. It is actually unusual to replace project directors because a project is not doing well. That is a fate usually reserved for the contractor project managers.

The turnover of the project director for an average upstream project is associated with a 30% decline in the probability of achieving a successful project even after first controlling for the effects of FEL ($Pr>|z|.004$). If the sample is restricted to oil and gas projects that achieved a *Good* or *Best Practical* level of FEL, those without a turnover in the project leadership were successful nearly two-thirds of the time, approximately as often as the equivalent non-E&P project. If the project director turned over, however, the success rate plummeted to less than one in three. By contrast, if the project director was replaced on a non-E&P project that was equally well front-end loaded, there was a mere 5% decline in the success rate that was not statistically significant.†

Two key conclusions can be drawn:

- Turnover of the project director is quite devastating for oil and gas megaprojects, even if the team has properly prepared for and developed the project.

- The effects of turnover are more severe for oil and gas megaprojects than for other industrial megaprojects.

**Recall that cost growth is calculated after all effects of escalation have been removed.

†Another difference is that turnover in the project director in upstream projects is more likely when FEL is poorer, but the correlation coefficient is only 0.19. It is statistically significant, but not nearly colinear. In non-upstream megaprojects, there is no relationship at all between the two variables.

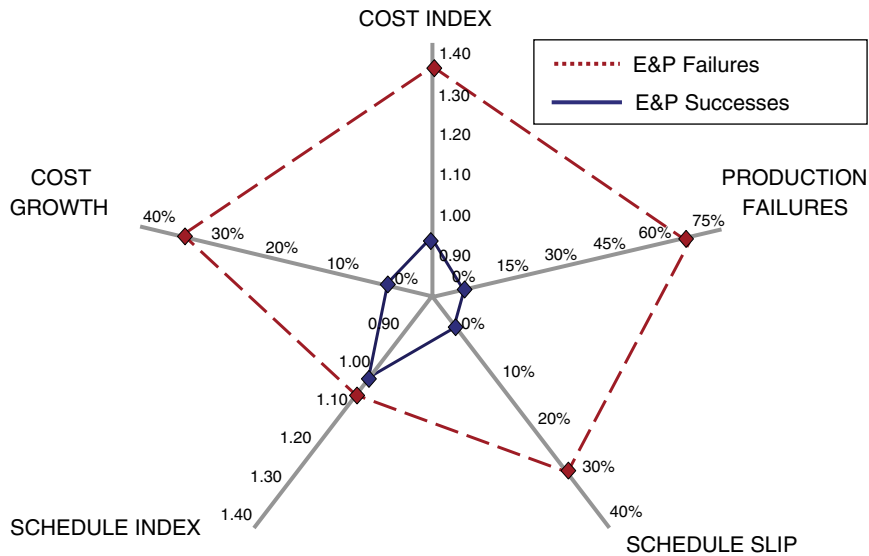


Fig. 1—E&P megaproject successes and failures: striking differences in performance.

Complete FEL Is More Important for Petroleum Development Megaprojects

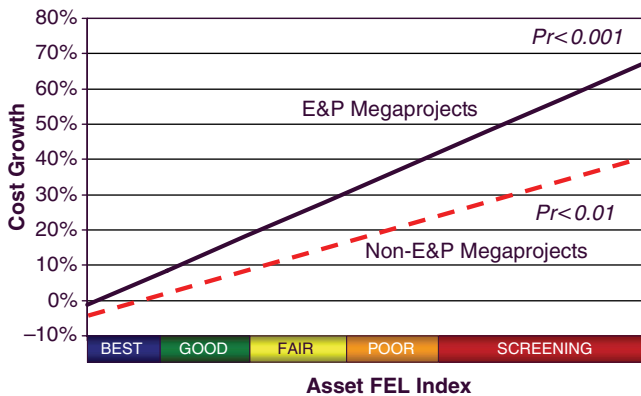


Fig. 2—FEL and the cost of E&P megaprojects.

• Therefore, there is some feature of upstream projects that makes the project director position uniquely important.

The Drive for Speed

The most important difference between upstream and other industrial megaprojects is found in the schedule strategy. Outside E&P, the strategy is usually to set the project's duration at or close to the average speed achieved by equivalent projects executed in the past. Fifty-four percent of upstream projects were explicitly "schedule driven." This designator is given to a project when the business has instructed the project team to minimize the time to first production or set a schedule to first production that is much faster (15% or more) than industry average for equivalent projects; in these projects, the business is willing to increase the capital expenditure (CAPEX) to achieve the schedule target. Only 32% of non-E&P megaprojects were schedule driven. The difference is clearly statistically significant ($Pr > |\chi^2| < .01$).

Another measure of schedule strategy is the relationship between the schedule established at FID and the schedule typically achieved by equivalent projects. We call this measure "schedule aggressiveness." The actual Schedule Aggressiveness Index for non-oil and gas megaprojects averages 1.05; that is, the schedule is 5% longer than what is usually required. Upstream projects average a Schedule Aggressiveness Index of 0.90 and the median index was even more heroic at 0.87. Oil and gas projects routinely establish schedule targets for execution that cannot be met.

The drive for *unobtainable* speed to first oil is crippling the industry. It is driving up cost by many tens of billions of dollars in CAPEX each year, and it is driving down production attainment after first oil is achieved. The cost index, a measure of CAPEX competitiveness, for schedule-driven upstream projects was an astounding 142% of the industry average. After slipping their aggressive schedules, the projects ended up slower than average—and, after all the effort associated with executing a schedule-driven project, 59% of the projects suffered severe problems with production attainment.. (Although the drive for speed is understandable in an era of high oil prices, this result forfeits almost all of the gain that the high prices might have brought the industry.)

When a project attempts to achieve unobtainable speed, the quality of all work that goes into successful projects begins to erode. This often starts with the completeness of the reservoir appraisal, which explains many of the production attainment disappointments. FEL for both facilities and wells is short-cut, which sets the project up for many late changes during execution; then, in a final twist, we are much more likely to turn over the project director position at least once if the project is schedule driven, a result that undermines the goal.* Seventy-seven percent of schedule-driven upstream megaprojects suffered a turnover versus half of the non-schedule-driven projects, which is higher than the average for all non-upstream megaprojects.

What Makes Speed Unobtainable?

I am sure we can all agree that rapid development of petroleum resources is, other things being equal, better than slower develop-

*It is difficult to understand why the industry turns over the project director position so much more often on schedule-driven projects. In some cases, burnout was clearly the problem. But overall, it is a perverse result.

ment. The problem is that those “other things” are often not equal. Shorter development cycle times to first oil followed by severe production attainment shortfalls is not a success. A huge overspend in CAPEX means that some other project will not be funded.

Yet, sometimes speed is achieved without losing excellence in other dimensions. This leads the financial analysts who track the industry to bemoan the slow pace of developments, especially by the large companies. However, what is essential for speed with excellence is the one thing that the large petroleum companies absolutely have not figured out how to achieve: *seamless functional integration*. A functionally integrated team is one in which the reservoir functions, facilities engineers, and drillers work in harmony and mutual comprehension. Ironically, smaller companies, the independents, are often able to achieve this ideal because of their small size and because each function and subfunction has not (yet) evolved into an organization with turf to defend and walls to build. Given the way that large companies organize large developments, the financial analysts who are pushing the businesses to drive for speed are actually doing the industry a massive disservice.

Why Is the Project Director Position So Important?

At this point, I hope that the reader can answer this question immediately: Because the project director position is the glue that binds the functions together in large companies to provide some semblance of good functional integration. The project director is usually the only position that performs this vital function in most upstream megaprojects.

The key organizational problem is our insistence on establishing separate reservoir, facilities, and wells teams and then trying to cobble them together into a coherent whole. Sometimes it works; often, it does not. When it works, it is often because the project leadership has assumed the role of functional integrator for the development. That person becomes the glue that binds the entire development together. When we replace this person, we dissolve the glue and *dis-integrate* [sic] the effort.

In other industries, approaches to asset development have not evolved with the degree of separation between functions that is so prevalent in the petroleum industry. As a consequence, in those in-

dustries, the functions are better integrated at the outset, rendering the role of the project director less important.

Conclusion

Unless or until large E&P organizations find a way to achieve deep functional integration, they need to stop listening to the siren song of speed for the sake of speed. Instead, they need to learn the virtues of patience and discipline, which are at least a little more common in other industries.

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Ed Morrow is the founder and President of Independent Project Analysis (IPA), Inc. Established in 1987, IPA provides a unique project research capability for the process and extraction industries. IPA has grown from a one-person organization to over 200 employees with offices in North and South America, the United Kingdom, The Netherlands, Australia, Singapore, and China. After receiving degrees from Dartmouth College and Princeton University, Morrow served as an Assistant Professor at UCLA, where he taught mathematical economic modeling and industrial organization. He then joined the Rand Corporation, where he developed and directed Rand's Energy Program and Research Program for the Chemical Process Industries. After 14 years with Rand, he left in 1987 to form IPA. He received the 2007 Construction Industry Institute's highest honor, the Carroll H. Dunn Award of Excellence, and the 2001 Engineering and Construction Contracting (ECC) Division Award for Outstanding Contributions to the Industry. Morrow has delivered hundreds of keynote speeches for major companies and organizations regarding capital project management and performance around the world, in addition to testifying before the U.S. Congress in matters pertaining to overruns in major capital projects. His years of analysis and research have culminated in the publication of his latest work, *Industrial Megaprojects—Concepts, Strategies, and Practices for Success*.