by Ernest Granson

Alberta's oilsands makes megaproject susceptible to big risks yet big rewards. *Photo courtesy Nexen.*

Blueprint for success?

How megaprojects are causing megaproblems

Throughout time, mankind has been compelled to build awe-inspiring megastructures — from Egypt's Great Pyramid to Boston's "Big Dig," an eight-to-10 lane highway completed in 2007 at a cost of $14.8 billion that runs through a 5.6-kilometre tunnel underneath the middle of the city.

Size, however, has proved to be a double-edge sword — neither Pharaoh Khufuto's pyramid nor Beantown's freeway were acceptable as a business models. And they are not alone. An estimated 68 per cent of megaprojects fail to meet the objectives established at authorization, according to Independent Project Analysis Inc. (IPA), a widely recognized global consulting company, with head offices in Virginia. A megaproject, in this case, is defined as a project costing at least $1 billion US in capital.

The outcome of a project begins to degrade very rapidly when the capital cost exceeds $900 million, says IPA founder and president Edward Merrow, author of *Industrial Megaprojects — Concepts, Strategies, and Practices for Success.* Below that $900-million benchmark, it's possible to control a project's outcome. Above that, and chasms begin to develop between what's considered successful and disastrous, he says.

Western Canada has had its share of megaprojects — not to mention its share of failures, says Merrow. In a keynote address to a Construction Owners Association of Alberta conference in Edmonton in 2011, Merrow presented a number of blunt statements about the negative image attached to Alberta megaprojects during the first decade of the 21st century.

Merrow noted the province, which previously had been considered a good place to develop projects, cultivated a distinctly poor reputation among international owners, some of whom criticized what they called "disastrous, out-of-control" cost overruns, "terrible" engineering and labor productivity and lack of construction management.

However, Merrow also pointed out that Alberta megaprojects are, by no means, alone in the battle to become successful. Two-thirds of large industrial international projects have failed over the past decade.

IPA's research on hot markets such as in western Australia, Alberta, the Middle East and the post-Katrina USGC indicate that project costs rose 10 to 20 per cent on average.

So the question is simple. Why do large projects fail so often?

Merrow points to four causes: unclear business objectives, failure to fully staff the owner team, poor front-end loading (project definition) and excessive turnover of owner staff. Incidentally, Merrow also points out that all of these practices are the owners' responsibility.

IPA North America regional director Elizabeth Sanborn believes the No. 1 issue is to fully define the project to ensure its successful completion.

"What are the project objectives? Does it meet the business needs?" she asks.

"Once you have a well-defined project, then you focus on your engineering. But the precursor to that is to close the scope. The scope is determined by the project's size, its location, the site characteristics and the infrastructure.

In the case of SAGD operations, sometimes there is expansion on existing facilities. But is it new, asks Sanborn. If so, the reservoir must be appraised, then the facility has to meet the characteristics of the bitumen. And if it's a LNG situation, the quality of gas must be appraised, she adds.

"So, we walk through a project and define the scope, which needs to be closed prior to process design," says Sanborn.

"That is when the engineering comes in. Monitoring the progress on engineering is critical to success. If there's late vendor data, engineering will be put behind. If the sequencing of the engineering is off track, it has a ripple effect on the construction and affects the whole project. That could result in delays of the engineering packages, and the labour could show up with nothing to install.

"These are not problems of inefficiency. It all goes back to the front end of the project."

But Sanborn says Western Canadian megaprojects have their own set of factors that have led to a significant failure rate — approximately two-thirds fail. And while these projects are inherently fragile, she suggests it's not necessarily because of their complexity.

"The sheer size of the projects means it requires multiple interfaces, which escalates the amount of planning and monitoring," says Sanborn.

"As you would expect, in an oilsands situation, there are three major functional areas that must work together; the petroleum reservoir, the wells and the facilities. All of these are necessary. But there are so many more factors to consider.

Take, for instance, the effect of a market environment such as in Houston, she adds. The supply chain there is robust. Yet even there, a megaproject could have major problems.

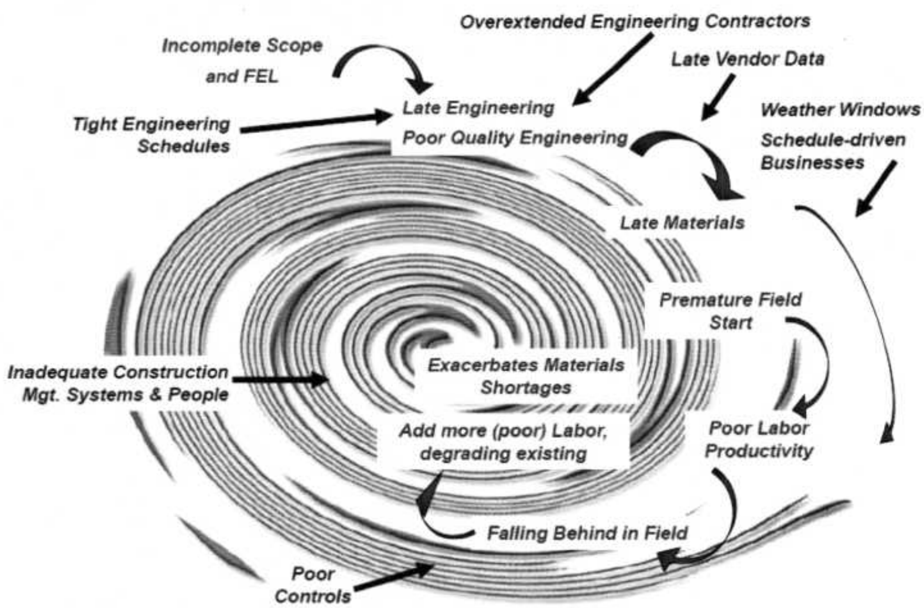
"In Canada, not only could the supply chain be weaker, but there is also the harsh climate, difficulty in retaining labour, First Nations relations and the regulatory environment with which to deal," says Sanborn, noting, despite those obstacles, IPA does have Western Canadian clients that do "quite well." Still, with narrow margins in the oilsands sector and the nature of the market, those same clients are also investigating all angles to attain success.

Most Key Outcomes Degrade with Size

As Project Size Increases	Outcome	Probability
Cost Growth	Increases	0.001
Cost Competitiveness	Gets worse	0.0001
Schedule Slip	Decreases up to $650 million and then increases	0.001 0.03
Operability	Declines	0.02

Source: Independent Project Analysis Inc.

IPA's Study of the Drivers of Poor Productivity
The Downward Spiral Starts with Incomplete Definition



"Right now, there are Western Canadian projects that are operating on the margins of profitability and are eager to understand what strategies and practices they can employ to improve their capital efficiency," says Sanborn.

"It may be standardization of design — that is, repeating the design in order to get better at it. It may be modular construction to deal with the weather windows. Modular construction can be successful, and 70 per cent of projects use this technique to move their labor into shops.

"But even that will not be successful if the correct information isn't passed on to the fab shops so they can come in on time. It all goes back to the early integration of the function to the stakeholder and not placing orders of equipment before you know what you want."

Financing also plays an important role in ensuring a project achieves its goal.

"In Western Canada, we don't see the external investors as much, but the JV (joint venture) nature in Western Canada does add another element of complexity," says Sanborn.

"What we're seeing now are cash-flow restraints since significant amounts are tied up in these mega investments and investors are being very careful in choosing their portfolios. If half of available investments are committed to one project, there's not a lot of money to go around."

Sanborn says IPA's objective with all of its clients is to help improve effectiveness through practices.

"We do a risk assessment well prior to authorization, and then look at the project when it's complete to identify how successful it is," she says.

Sorting out the logistics

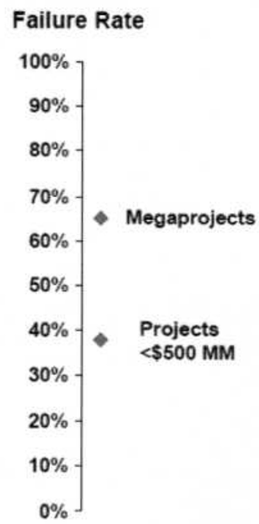
While modularization is widely used to manufacture facility components in climates such as northern Alberta's, even this has its

Defining Success and Failure

We deem a project to be a failure if one or more of the following occurred:

Costs grew (real)	25% +
Schedule Slipped	25% +
Overspent *(Absolute Measure)*	25% +
Execution time *(Absolute Measure)*	50% +
Severe and Continuing Operational Problems into Year 2 after startup	Yes

Source: Independent Project Analysis Inc.



challenges, says Ming Lu, associate professor of construction engineering and management at the University of Alberta's Department of Civil and Environmental Engineering.

Even though Alberta's construction sector is adept at modular construction, decision-making practices still lack quantitative support, he suggests.

In a recent paper by Lu and Tony Wu, PC lead and project controls manager of strategic planning at Suncor Energy, the authors propose that the industry needs to implement quantitative methodology "to meet field construction demands and satisfying constraints such as budget, contractors' production capacities, road bans and transportation conditions, module size, freight shipping limits, site layout and capacities of temporary site facilities."

The paper — entitled *Modularization Program Execution Optimization on Mega Oil Sands Projects*, and written for AACE International (formerly Association for the Advancement of Cost Engineering) —suggests this methodology could potentially improve overall project management for owner companies by streamlining decision-making and planning processes, most notably for the modular construction of mega projects.

Lu and Wu categorize modules built for oilsands processing facilities into four categories according to functionalities and components:

- **Piperack Module:** consists of mostly pipe (for example, utilities and off-site pipe rack modules);
- **Equipment/Process Module:** consists of tagged or packaged equipment with pipe (for example, heat exchanger, vessel, deluge package, power generators, hydraulic skid);
- **Steel Module:** consists of structural steel without pipe (for example, steel frames, steel stairs, and towers);
- **Electrical Module/Building:** consists of electrical components such as an electrical cable tray, cable/wire, and instrumentation (for example, substations, I/O buildings)."

"There is a complete system in place that already works to deal with the planning necessary to produce, transport and install those modular components," says Lu, who worked as an adviser with the Beijing Urban Construction Group on logistics and installation sequence optimization of prefabricated structural steel components during the construction of "Bird's Nest" Beijing Olympic Stadium.

"But because the megaprojects are so much bigger and complicated, and because there are so many parties involved, the communications aspect is a huge challenge and how to provide quantitative decision support just in time while accounting for sufficient details with limited availability of data is a daunting task.

"The decisions based on the information being communicated involves high stakes. The scope is so enormous. It's like placing a bet on hundreds of millions of dollars of products. And, in many ways, that decision-making is still based on experience and a feel by engineer or manager."

Megaproject planning is still subject to logistics difficulties because bidding decisions are largely based on cost estimates (unit prices and quantity takeoffs), yet information related to contractors' available resources and achievable production rates is quite limited, says Lu and Wu. Without this reliable data, it is virtually impossible to make accurate long-range plans. This data shortage has prevented the development of mathematical software algorithms to use for planning purposes.

Project management software does exist — such as Primavera P6, an Oracle Corp. application that offers specialized management capabilities. Ye Lu notes they are often limited — in Primaver P6's case, its limited to oilsands megaproject applications in terms of project planning.

To overcome the current limited software, Lu has developed a prototype software based on new research of resource-constrained schedule optimization. He hopes it can meet both the field construction demands and satisfy constraints such as budget, contractors' production capacities, road bans and transportation conditions, module size, freight shipping limits, site layout and capacities of temporary site facilities.

To do this, the software combines resource-constrained scheduling and Monte Carlo simulation-based risk analysis to gain insight into the production capacity and the schedule of a potential contractor, utilizing the limited historical data. This has produced quantitative decision support for the owner to make crucial decisions in evaluating a contractor's bid proposal, such as the minimal production capacity of a contractor's module yard and a realistic schedule to deliver the module fabrication.

A Monte Carlo simulation uses a range of possible values, instead of a single guess, to predict what could happen. It's different from most forecasting models that use specific, fixed estimates. Random values are selected based on a range of estimates and a model calculated on the random values. The process is repeated many times using different randomly selected values, resulting in a large number of results being available that can be used to illustrate the probability of achieving the various results in the model.

"I use the software for project consulting for companies, but it is still a research prototype, although it may have potential to be further marketed," Lu says.

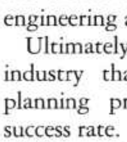
"I believe it can help provide more insight and relevant decision support, but it still won't replace human decision makers.

"And, while the purpose of modular fabrication is meant to simulate manufacturing in order to lower costs, it does create complexities. We can fabricate the components in a factory in Edmonton and save on labour costs, but it also creates logistics challenges, such as design, engineering and delivery time."

Ultimately, Lu's objective is to show those industry that implement improvements to planning practices can alter megaprojects' success rate.

"There exists such a tremendous need to improve the status quo in connection with construction estimating, planning and control on Alberta's mega projects, but those involved in the planning process are so preoccupied or busy with the day-to-day battles," he says.

"The overall process does work and has produced amazing accomplishments, so it is extremely difficult to integrate new ideas or new tools into the existing process. It's a bottleneck. How to integrate all of the advanced technologies with all of the involved parties into the existing processes is not a technology problem; it's a communication and culture issue. People see the issue, but it appears, from my experience, that they haven't yet seen any real game changer solution that can be inserted into the process."



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