

INDUSTRIAL MEGAPROJECTS

Concepts, Strategies, and Practices for Success

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John Wiley & Sons, Inc.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

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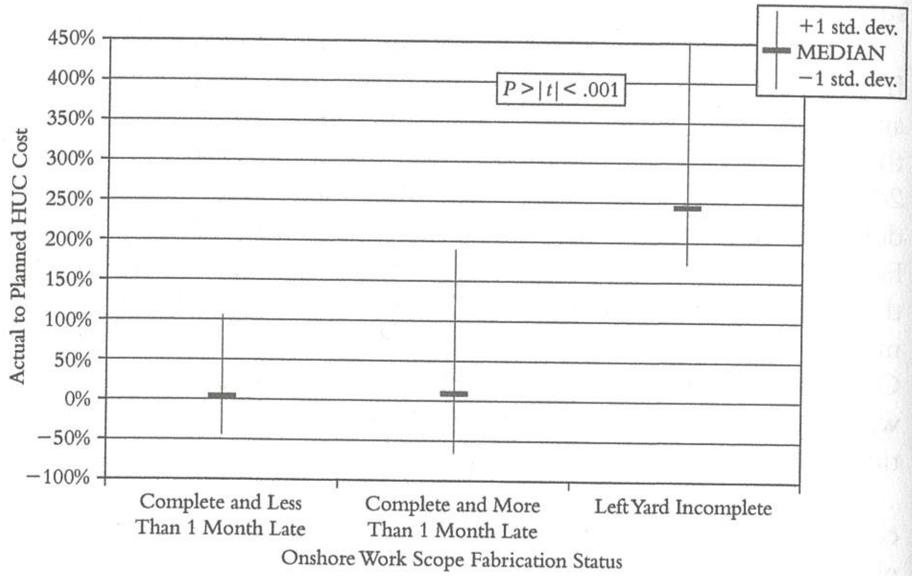
Library of Congress Cataloging-in-Publication Data:

Merrow, Edward W.
Industrial megaprojects : concepts, strategies, and practices for success / Edward W. Merrow.
p. cm.
Includes index.
ISBN 978-0-470-93882-9 (cloth)
ISBN 978-1-118-06748-2 (ebk)
ISBN 978-1-118-06749-9 (ebk)
ISBN 978-1-118-06750-5 (ebk)
1. Project management. I. Title.
HD69.P75M47 2011
658.4'04—dc22 2010054037

Printed in the United States of America

V10005003_100518

Figure 12.6
Carrying Fabrication Work Offshore Is Expensive



RISK MANAGEMENT PRACTICES

Almost all of the projects in our sample were subjected to a series of risk management exercises, starting in FEL. Because so many practices were applied to so many of the projects, it is difficult to explore the effectiveness of the practices statistically. Our research on the use of risk management practices on smaller projects suggests that there is value in things like brainstorming sessions for risks; structured brainstorming of strengths, weaknesses, opportunities, and threats (SWOTs); and so forth. Our research around the use of peer reviews on smaller projects suggests they are of very limited use and may even cause harm by injecting too much conservatism into cost estimates.

Exercises that sensitize team members to potential problems down the road must surely be worthwhile. But we all must remember that the very basis of risk management is sound basic practice around things such as clear business objectives, team staffing and integration, and thorough FEL. In the absence of those things, layering on risk management practices is a futile exercise.

What I do not see in most risk identification, mitigation, and management exercises is a process for identifying the leading indicators of trouble and then working through exactly how the project team will respond in the event that the problem starts to materialize. For example, very few projects had a backup plan for how to respond if the detailed engineering started to fall behind. Virtually none of the projects that needed to be ready to shift the start of construction, for example, were actually ready to do so. The right to intervene when engineering is falling behind must be stipulated in the contracts with the engineering and construction/fabrication firms.

I believe the way we approach risk management on megaprojects needs to be different than standard technique. I believe it needs to focus almost entirely on "what if" planning. Using real examples, how will we, as an owner team, actually intervene in the process in the following situations, and others:

- The contractor is in violation of government rules around bringing people into the country.
- The businesses make a significant scope change during ___________. (Fill in the blank.)
- The government makes a rule change around ___________. (Fill in the blank.)

The focus traditionally is on identification of potential problems, entering those problems into a risk register, assigning a (usually junior) person as a "risk manager," and forgetting about it. Too often when a previously identified problem actually occurs, the project director and team are not prepared to respond because the response has not been worked through in advance.

RISK MODELING: A TALE OF TWO PRACTICES

Two types of modeling are routinely practiced on large projects:

1. Monte Carlo simulation of cost risk, usually with an eye to setting the appropriate contingency
2. Probabilistic analysis of the authorization schedule to assess the reasonableness of the forecast time requirement

Although these practices appear similar, they actually have very different efficacy. Monte Carlo (and variations) simulation of cost is less than worthless; it actually does harm. Probabilistic schedule analysis is very useful.

Monte Carlo Cost Risk Simulation Does Not Work

Of the projects in our sample, 61 percent used Monte Carlo simulation to model the probability that the authorization cost estimate would overrun (or underrun, but that is rarely an issue). Monte Carlo is a simulation technique for aggregating a series of distributions of elements into a distribution of the whole. It was developed to shortcut the cumbersome mathematical task of summing distributions. There are several underlying assumptions for the accuracy of the technique, the most important of which is orthogonality; that is, every distribution must be independent of every other distribution or the interdependencies must be accurately modeled and incorporated into the simulation.

When Monte Carlo is used to model cost risk, the procedure is first to develop the estimated cost of the project using normal practice for sanction estimates. Then, using a combination of team members and experts, a distribution is assigned around each element. For example, the cost of field labor (or any of its subelements) would be assigned an amount above and below the estimated value. The distribution might incorporate risk around both changes (increases) in hourly cost and productivity. An interdependency with the distribution around bulk material quantities might also be introduced.

After all of the distributions around all the elements in the estimate have been assigned, the simulation routine is run with samples randomly from the distributions as a function of the density of each distribution. The result from several thousand runs then forms the new composite distribution of cost risk. The contingency is set based on the probability of not overrunning that is desired, usually about 60 percent of not overrunning.

So does it work? For a risk modeling technique to be said to work, it must relate in a systematic way to the things that are first principle drivers of risk. As we have established, team integration, adequacy of team staffing, and most especially, FEL are the primary drivers of cost

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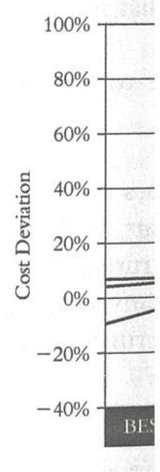
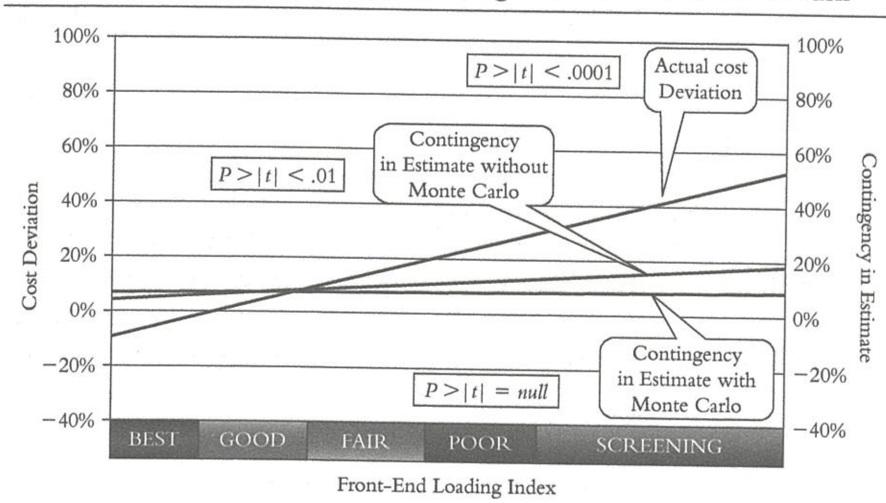


overrun risk on projects. So if Monte Carlo simulation is working, it should result in contingencies that correlate well with those factors. We would also hope that Monte Carlo simulation results would correlate better than when the technique was not used, or one might conclude it is a waste of time.

Lacking an integrated team adds to risk. When Monte Carlo simulation is not used, project teams are reflecting that risk with higher contingency ($P\ |t| < .0001$). When Monte Carlo simulation is used, contingencies are actually *lower* but the result is not statistically significant ($P\ |t| < .08$). There is no relationship between Monte Carlo use and contingency when team staffing was not adequate. The real killer for Monte Carlo simulation comes from the relationship between contingency and FEL with Monte Carlo simulation used. That is what Figure 12.7 shows.

Three relationships are shown in the figure. The first is the actual relationship between cost deviation (the ratio of actual to authorization estimated cost) and the FEL index. The relationship is very strong and remains so no matter what other factors are introduced. It is a true driver of risk. The bottom line is the relationship between

Figure 12.7
Monte Carlo Generated Cost Contingencies Are Unrelated to Risk



FEL and contingency when Monte Carlo simulation is employed. The line is flat. Monte Carlo simulation is producing an average contingency of 9 percent, with a standard deviation of less than 4 percent, independent of any first principle elements of risk. Remarkably, that distribution is normally distributed when we would fully expect it to be sharply skewed to the right. The average megaproject cost estimate when Monte Carlo simulation was used overran by 21 percent, with a standard deviation of 26 percent and a sharp right skew.

When Monte Carlo simulation was not used, teams were actually more sensitive to basic risks as they set contingency. A slope that is statistically significant at less than 1 chance in 100 does exist between contingency and the FEL index when Monte Carlo simulation is not used. This is why I have to conclude that Monte Carlo simulation actually does harm; it is not merely worthless.* The use of Monte Carlo simulation has no relationship to success of megaprojects or any of our other five figures of merit of projects: cost growth, cost competitiveness, schedule slippage, schedule competitiveness, or production attainment.

So why is Monte Carlo simulation so widely used? I believe it is because it seems so plausible. The Monte Carlo simulation results have, to use Stephen Colbert's wonderful word, the feel of *truthiness* about them, that is, the sense of being true without any of the burden of actually being true.† After all, a "scientific simulator" generated these results, not mere humans! Monte Carlo simulation is also easy to use and has given birth to a substantial cottage industry that is deeply invested in the approach.

The reasons that Monte Carlo simulation fails are basic to the tool itself and its application to the problem:

- Monte Carlo simulation is merely a simulator that does an excellent job aggregating distributions. The problems start with the distributions themselves. Cost estimates rarely overrun because there were errors in getting the distribution around any individual element in the estimate right. Cost estimates overrun because

*These results hold for smaller projects as well.

†Until truthiness came along, I referred to the Monte Carlo simulation results as a thin gloss of scientific verisimilitude on pure BS. Truthiness is more succinct.

the scope was not all defined, which means that the central value of every element in the estimate was wrong.

- The distributions used in the Monte Carlo analysis are fabrications. By that I do not mean they are lies but that they are made up—fabricated—by a group. They are not based on historically observed distributions of outcomes, nor do they have any first principles basis. They are opinion. Behavioral research dating back to the mid-1950s and Ward Edwards' Engineering Psychology Group at the University of Michigan has shown that when experts are asked to posit a distribution around some event, they will tend to make the distribution much more peaked and normally distributed than it actually is. That means that the distributions used in Monte Carlo simulation will actually tend to be systematically biased toward less variance. This is exactly what we observe in the data. Instead of a mean of 9 percent contingency with a near-normal distribution, we observe a 30 percent (9 percent plus the actual 21 percent overrun) mean with a sharply skewed distribution. Instead of a standard deviation of 4 percent, we should have seen a standard deviation in excess of 25 percent.
- The orthogonality assumption, which is absolutely central to the mathematical integrity of Monte Carlo simulation, is grossly violated by the real world of projects, large and small. In projects, bad things tend to happen in groups, not individually, because projects are so tightly woven. Events that affect projects in major ways, such as scope changes, engineering errors, erratic business decision making, or poor FEL, tend to go together. Even when one of those things occurs individually, it tends to trigger a cascade of problematic effects. Defenders of Monte Carlo simulation will sometimes respond to this criticism by saying that the interdependencies can be modeled. That is pure fantasy.

PROBABILISTIC SCHEDULE ASSESSMENT DOES WORK

If Monte Carlo simulation of cost risk is a complete flop, probabilistic evaluation of schedule has proved a useful technique for megaprojects. Probabilistic schedule assessment (PSA) involves examining the elements on or near the critical path for a project and testing how varying the durations of critical elements changes the overall schedule duration. PSA is asking the question, How likely is it that everything will go according to plan?

The use of PSA at project authorization is associated with a 27 percent decrease in the amount of execution schedule slippage by the projects ($P\ |t| < .001$). The use of PSA is helping project teams see that their chances of achieving the schedules that have been established are very poor. That then causes them to insert float at various points that are defined as low probability of achievement. Setting realistic schedules is associated with better overall results. The use of PSA is associated with a lower probability of production attainment failure as well as lowered schedule slippage. More realistic schedules improve quality. Improved quality plays out in better operability.

Reading the Tea Leaves: Key Warning Signs of Trouble Ahead

The period from late FEL through early execution is a very busy period for project teams. It is easy for them to be too busy to begin thinking about risk surveillance. But this period is about the last chance during which an impending disaster might be averted. To see if any telltale signs of trouble could be seen, I reviewed the project histories for any events that recurred from very late FEL through the first few months of execution that might have provided early enough warning of trouble to come that changes could be made, especially changes in schedule. I list an event only if it occurred in three or more failed projects and did not appear more than once in successful projects.

Changes

- Were any scope changes made during FEED? Scope changes in FEL-3 are strongly associated with detailed engineering being late.
- Has a change in the nameplate capacity occurred that was based on using up design margins in equipment? This is not really a scope change because it does not involve new equipment, merely