Unknowns, Systemic Risks and Risk Prioritization in Schedule Risk Analysis

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Secretary Rumsfeld’s use of “Unknown Unknowns”

In February 2002 DOD Secretary Donald Rumsfeld stated: “Reports that say that something hasn't happened are always interesting to me, because as we know:

There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know.

And if one looks throughout the history of our country and other free countries, it is the latter category that tend to be the difficult ones.”

Uncertainty including Inherent Variability, Estimating Error, Estimating Bias

• Inherent variability in project activities that arise because people and organizations cannot do things reliably on plan
• Estimating error – attaches to all types of estimates
• Estimating bias – estimates may be slanted, usually toward shorter durations, to make desired project results

“There are No Facts About the Future”

Lincoln Moses, Statistician and Administrator of Energy Information in the US DOE 1977 Annual Report to Congress

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Uncertainty

• Uncertainty in schedule duration is similar to “common cause” variation related to six sigma management, concepts developed by Walter Shewhart and championed by Edwards Demming

• “Common cause variability is a source of variation caused by unknown factors that result in a steady but random distribution of output around the average of the data .... Common cause variation is also called random variation, noise, non-controllable variation ...” (http://www.isixsigma.com/dictionary/common-cause-variation/ )

• Hence application of uncertainty alone establishes the earliest date that risk mitigation can achieve even if individual risks were fully mitigated
Example Schedule: Offshore Gas Production Platform Project
Offshore Gas Production Platform Construction project, 3+ years and $1.7 billion. Using Polaris© from Booz Allen Hamilton.
Correcting for Inherent Variability, Estimating Error and Bias

• Schedule uncertainty exhibiting inherent variation, estimating uncertainty and bias with ranges of .9, 1.05 and 1.3
• To replicate the estimated overall project ranges by using these parameters for individual activities we need to correlate the uncertainty

Without Correlation
P-80 duration is 113% of planned
With Correlation at 1.0 the P-80 duration is 116% of planned
Variation Caused by Known Unknowns

• Project-specific risks are:
  – Characterized by probability of occurring that is usually less than 100%
  – Represent “root causes” of variation in durations
  – May be reducible by risk mitigation actions

• These are specified during risk interviews and implemented with:
  – Estimated probabilities
  – Impact ranges (3-point estimates of multiplicative factors called Risk Drivers”) if they occur
  – The activities or cost elements they influence

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Project-Specific Risks, Pre-Mitigated

• Risk is similar to “special causes” in six sigma

• “... special cause variation is caused by known factors that result in a non-random distribution of output...Special cause variation is a shift in output caused by a specific factor such as environmental conditions or process input parameters. It can be accounted for directly and potentially removed...”
  (http://www.isixsigma.com/dictionary/variation-special-cause/)

• Hence, pre-mitigated risks are the subject of risk mitigation workshops. The improvement from risk mitigation is limited by the date determined by uncertainty alone
There are 8 project-specific Risk Drivers including one Organizational Risk Driver assigned to all activities. Probability and impact multiplier ranges are specified, risks are assigned to activities. A risk can affect many activities, and an activity can be affected by several risks.
Adding Project Specific Risk Drivers

Adding Project-Specific Risk Drivers increases P-80 Duration to 125% of planned
Unknown Unknowns
May Not be Unknowable

• Interviews or workshops on risk often focus on risks and uncertainties that are close-in or actually happening now
  – This myopia leads to insufficient consideration of future risks

• It is arguable that some unknown unknowns are not truly unknowable but just have not been thought of yet

• Extra effort to focus on down-stream risks during the risk interviews could improve our understanding of risks, including making some of these “Unknown Unknowns” known
Add a Fourth Category of “Unknown Knowns”

• Psychoanalytic philosopher Slavoj Zizek says that beyond these three categories there is a fourth, the unknown known, that which we intentionally refuse to acknowledge that we know

• German sociologists Daase and Kessler (2007) agree with a basic point of Rumsfeld in stating that the cognitive frame for political practice may be determined by the relationship between what we know, what we do not know, what we cannot know, but Rumsfeld having left out what we do not like to know

http://en.wikipedia.org/wiki/There_are_known_knowns, Cited 12/26/2015
Risk Interviews vs. Risk Workshops (1)

- **Risk Interviews** provide a safe environment to discuss both Unknown Unknowns and Unknown Knowns
- **Specifically, Unknown Knowns**
  - We find that the *Risk Register is always incomplete*
  - Many of the risk events found to be most important in determining the schedule risk results are not in the Risk Register at all
  - These can be safely discussed in one-on-one interviews where confidentiality is promised
- **In these interviews new risks are discussed, whether they are hurtful to the project or embarrassing or not**
  - Responding to open-ended questions, interviewees are encouraged to talk about “the good, the bad and the ugly”
Risk Interviews vs. Risk Workshops (2)

• We need to avoid the ostrich approach to risk management. Identify, talk about and quantify the Unknown Knowns, the “elephant in the room,” and tell unbiased results

• Risk interviews provide a confidential environment where individuals can talk in depth without being afraid of being embarrassed, pressured or subjected to “shoot the messenger”

• Conversely, Risk Workshops often are places where social pressures or group dynamics limit debate
  – Groupthink – prefer unanimity, discourage dissent
  – “Moses factor” – adopting influential person’s ideas
  – Cultural Conformity – decisions match the group’s norms
Considering Systemic Risks
Compare what Risk Analysis Typically Predicts vs. What Actually Happens

When an engineer says their estimate is +/-10% they mean...IF nothing changes, no risk events occur, and control is excellent. They say this because they can’t control these things...but we must estimate Reality

Source: John K. Hollmann, PE, “Reliable Risk Quantification for Project Cost and Schedule”, AACE International webinar December 15, 2015
Incorporate Systemic Risks into the Monte Carlo Simulation (MCS)

• Systemic Risks that include:
  – Technical complexity, new technology challenging
  – Scope not fully known
  – Process definition not complete
  – Megaproject complexity, size / duration, participants
  – Project organization, e.g., joint venture, multiple EPCs
  – Project management, scheduling and estimating process, bias

• Some argue that these factors can be measured and their impact on project success estimated using parametric techniques
Inserting 3 Megaproject Systemic Risks with Original Uncertainty

• Identifying the systemic risks and inserting them with appropriately-large impacts allows us to:
  – Specify the probability of occurrence
  – Identify the risks for risk mitigation

• In this case study, these megaproject risks:
  – May have interdependency issues between project elements
  – May have complex offshoring of supply chain and even EPC contractors
  – May have excessive schedule pressure “I want it sooner”
Megaproject Systemic Risk Example
Parameters for specific Megaproject Systemic Risks are challenging, need to be selected based on historical data.

We need to be sure to include the systemic risks with the right probability and impact ranges based on data into the Monte Carlo simulation.
Some suggest that megaprojects that come in at 25% or less (cost) over the sanction budget are considered successful. This curve shows that about 50% do so.

The P-80 duration is 1,913 days about 61% overrun of schedule.
Results are Similar to those for Cost Provided by IPA

Figure 8 - Cost Deviation Results for FEL 2 Estimates Compared to Actual Costs

“Quantifying Estimate Accuracy and Precision for the Process Industries: A Review of Industry Data” Alexander Ogilvie, Robert A. Brown, Jr., Fredrick P. Biery and Paul Barshop from IPA. IPA’s Front End Loading (FEL) 2 is “Scoping Facility Planning,” comparable to AACE International Class 4 estimates which gets a high range of +30% to +50%. This is not high enough
Risk Prioritization Method Illustrated
Problems with Typical Risk Prioritization Approaches

• Risk prioritization usually involves presenting:
  – Standard tornado diagrams based on correlation between activities and finish date
  – Risk tornado diagrams, based on correlation between risks and finish date
    • Correlation-based tornados have problems with risks that may or may not occur
  – Risk criticality based on activities’ being on the critical path

• None of these methods give management what they need to assess mitigations
  – Risks prioritized at the P-80, not means as in correlation
  – Risks measured in days saved if mitigated, not correlation coefficients
  – Risks have to be the arguments driving MCS to do this
## Prioritizing Risks using MCS

Selected by their Days Saved at P-80

<table>
<thead>
<tr>
<th>Risk #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority Level (Iteration #)</td>
<td>Abusive Bids</td>
<td>Offshore design firm</td>
<td>Suppliers Busy</td>
<td>Fab productivity</td>
<td>Geology unknown</td>
<td>Coordinating during Installation</td>
<td>Problems at HUC</td>
<td>Resources may go to other projects</td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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Risk Prioritization for Mitigation

Megaproject Systemic Risks
## Risk Prioritization Results for Risk Mitigation Workshop

### Risk Prioritization at P-80 with Days Saved

<table>
<thead>
<tr>
<th>Name</th>
<th>Days Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megaproject may have interdependency problems</td>
<td>245</td>
</tr>
<tr>
<td>Megaproject may have excessive schedule pressure</td>
<td>128</td>
</tr>
<tr>
<td>The organization has other priority projects so personnel and funding may be unavailable</td>
<td>54</td>
</tr>
<tr>
<td>Megaproject may have coordination problems offshore sourcing</td>
<td>46</td>
</tr>
<tr>
<td>Fabrication yards may experience lower Productivity than planned</td>
<td>25</td>
</tr>
<tr>
<td>Engineering may be complicated by using offshore design firm</td>
<td>12</td>
</tr>
<tr>
<td>Suppliers of installed equipment may be busy</td>
<td>13</td>
</tr>
<tr>
<td>Fabrication and installation problems may be revealed during HUC</td>
<td>9</td>
</tr>
<tr>
<td>Bids may be Abusive leading to delayed approval</td>
<td>1</td>
</tr>
<tr>
<td>Installation may be delayed due to coordination problems</td>
<td>1</td>
</tr>
<tr>
<td>The subsea geological conditions may be different than expected</td>
<td>0</td>
</tr>
</tbody>
</table>

**Days Saved from Project Specific and Systemic Risks**: 534

**Days Contributed by Uncertainty alone**: 189

**Total Days contingency at P-80**: 723
Risk Mitigation Workshop(s)

- This is a workshop with the project manager, deputy PM, team leads, controls personnel, SMEs with experience
- A mitigation action must be:
  - Different from what is being done now, or you get what you have now
  - Committed to by the organization
  - Budgeted, staffed, scheduled, owned
  - Monitored frequently, willing to admit when it is not working
- Do not get to take credit for mitigation actions that are not commitments
## Sample Risk Mitigation Entry

**Risk:** The organization has other priority projects so personnel and funding may be unavailable

<table>
<thead>
<tr>
<th>Probability</th>
<th>Low</th>
<th>Most Likely</th>
<th>High</th>
<th>P-80 Date</th>
<th>P-80 Cost (billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Mitigated parameters</td>
<td>65%</td>
<td>95%</td>
<td>105%</td>
<td>1/22/2018</td>
<td>$2.13</td>
</tr>
</tbody>
</table>

**Mitigation Action:** Establish this project as top priority - needs top management action and commitment

<table>
<thead>
<tr>
<th>Post -Mitigated parameters</th>
<th>15%</th>
<th>95%</th>
<th>100%</th>
<th>115%</th>
<th>10/20/2017</th>
<th>$1.99</th>
</tr>
</thead>
</table>

**Risk Owner:** S. Smith

**Date of Action:** Within 1 month

**Risk Action Owner:** B. Blake

**Days saved**

<table>
<thead>
<tr>
<th>Results</th>
<th>94</th>
<th>$0.14</th>
</tr>
</thead>
</table>

**Cost of Mitigation**

<table>
<thead>
<tr>
<th>Cost Saved</th>
<th>$0.02</th>
</tr>
</thead>
</table>

Risk is not completely mitigated. Cost saved is the reduction of cost contingency reserve held for schedule risk. For Net Cost Saved subtract the $20 million cost of mitigation.
Creating the Post-Mitigated Scenario

• A risk post-mitigated scenario can be constructed in the software
  – Partially mitigate each risk, in this case just by reducing probability by half
  – Estimate the cost of the risk, in this case each risk’s mitigation = $50 million
  – Run the post mitigated scenario
• When schedule risks are mitigated the cost contingency reserve can be reduced since some was held for schedule growth
• However, the cost of the project now includes the assumed $50 million cost of each mitigation
Partially Mitigate all Risks – Finish Date

Mitigating all risks (Here, just reducing the probability by half) moves the P-80 date by total mitigation time of about 7.5 months.
Partially Mitigate all Risks – Total Cost

Notice the effect of the mitigation costs – in the red circle – these are included and still there is some cost savings, largely from the schedule risk mitigation.
Summary (1)

• Unknown Unknowns are unknown today, but some may become known during confidential interviews

• A new category of “Unknown Knowns,” or those risks which are known to exist but are not talked about, is addressed
Summary (2)

• Confidential interviews allow interviewees to identify “unknown unknowns” and to discuss “unknown knowns”

• Interviewees introduce risks not included in the current Risk Register
  – Open ended questions often reveal important, embarrassing or potentially dangerous risks that are not talked about
  – Once introduced, other team members seem to be able to contribute to quantifying those “unspoken risks”
  – These “interview risks” are often more impactful than the risks in the Risk Register
Monte Carlo simulation methods have been challenged to address systemic risks

- Some say that systemic risks are best captured by parametric analysis

We show how systemic risks, often identified with megaprojects, can be handled in MCS, compared to simple expanding the uncertainty ranges

Project results databases need to be created or mined if they exist to determine the impact multipliers for systemic risks.
Summary (4)

- Risk mitigation decisions are greatly helped with prioritized risks
- Risks need to be prioritized at the target level of certainty, e.g., P-80
- Risks prioritization needs to supply some metric that management can use in a benefit / cost analysis, e.g., “days saved” even if assuming perfect mitigation
- These tables have been useful in mitigation workshops
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