Cost and Schedule Risk Analysis
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Agenda

• Definitions and Discussion
• Why Are We Doing This?
• Cost Dx Mission
• Risk Management Methodology
  – Risk Identification
  – Risk Analysis and Quantification
  – Risk Response/Mitigation Plan
  – Risk Monitoring and Control
• Practical Uses/Tips
• Conclusion/Questions
The Issue
Programming Estimates set Baseline or Budget

$\text{Actuals are lower than Programming Estimate}$

<table>
<thead>
<tr>
<th>Year</th>
<th>FY05</th>
<th>FY06</th>
<th>FY07</th>
<th>FY08</th>
</tr>
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</table>
Why Are We Doing This?

- Major General Riley Memo 3 Jul 2007
- E&C Bulletin 10 Sep 07
- ER 1110-2-1150 Engineering and Design for Civil Works Projects
- ER 1105-2-100 Planning Guidance Notebook
- ER 1110-2-1302 Civil Works Cost Engineering

**Per the PMBoK Guide:**

“The objectives of Project Risk Management are to increase the probability and impact of positive events, and decrease the probability and impact of events adverse to the project.”
Risk

An uncertain event or condition that, if it occurs, has a positive or negative effect on a project’s objectives.

Source: PMBoK® Guide, p. 373
What Are the Focus Areas?

- Cost Growth
- Poor Quality
- Late Delivery
- Political Fallout
- Safety Infraction
- Loss of Public Trust
Acquisition Life Cycle Cost Uncertainty

Source: GAO.
Risk Impact Behavior

Figure 2-2. Impact of Variable Based on Project Time

Top Reasons for Major Cost Variations

- Definition and Packaging of Product
- Clear Scope of Work
- Accurate Contingency Levels
- Defined Acquisition Strategy
- Accurate Quantities
- Estimate Details
- Other
Definitions

• Internal Risk: An item or activity upon which the PDT has control or influence.
• External Risk: An item or activity upon which the PDT has no control or influence.
• Discrete (Project, Contract, Specific) Risk: An item or activity that only affects a specific feature account.
• Global (Programmatic) Risk: An item or activity that affects multiple or all feature accounts.
### Basic Risk Assumptions

<table>
<thead>
<tr>
<th>Known Knowns</th>
<th>Why didn’t they say something sooner!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known Unknowns</td>
<td></td>
</tr>
<tr>
<td>Unknown Knowns</td>
<td></td>
</tr>
<tr>
<td>It might happen, but</td>
<td>Didn’t see that coming!</td>
</tr>
<tr>
<td>at least we know</td>
<td></td>
</tr>
<tr>
<td>about it.</td>
<td></td>
</tr>
</tbody>
</table>

We know it’s gonna happen.
Pareto Principle

Per the 80/20 rule of the Pareto Principle:

20% of the risks will cause

80% of the impacts
Definitions

Risk Management (PMBOK® Guide):

“Project Risk Management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project; most of these processes are updated throughout the project.”
Definitions

Risk Analysis (PMBOK® Guide):

Qualitative Risk Analysis: “Prioritizing risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact.”

Quantitative Risk Analysis: “Numerically analyzing the effect on overall project objectives of identified risks.”
Cost & Schedule Risk Analysis (CSRA)

- Technique used to improve development of contingencies
- Formal analysis required on all projects requiring authorization and anticipated to be $40 Million or more in total project cost
- Relies on qualitative and quantitative studies
- OUTPUT quality is limited by INPUT quality (inputs are estimates and schedules)
NWW Cost Dx Mission

• Review and certification of cost estimates (including MCACES estimates, schedules, and Total Project Cost Summaries which include contingencies) during feasibility level ATRs for all USACE Civil Works projects going up for authorization and funding.

• Development of risk analysis capability through the Cost Engineering CoP, as well as actually performing cost risk analyses (upon request) in its support for others role for projects with a total project cost of $40 Million or more.
Discussion/Concerns – CWE Process

CWE → ATR → Most Likely Estimate
   ↓               ↓
   Escalation       CSRA
   Contingency

ATR → TPCS

Most Likely Estimate → Feasibility Report/PACR
Risk Methodology (PMI)

- Project Delivery Team (within PMP)
- Risk Management Planning
- Risk Identification
- Risk Analysis and Quantification
- Risk Response/Mitigation Plan
- Risk Monitoring and Control
# Responsibilities for Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Lead</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management Planning</td>
<td>PM</td>
<td>PDT</td>
</tr>
<tr>
<td>Risk Identification</td>
<td>PM</td>
<td>PDT</td>
</tr>
<tr>
<td>Risk Analysis and Quantification</td>
<td>Cost Engineer</td>
<td>PDT</td>
</tr>
<tr>
<td>Risk Response/Mitigation Plan</td>
<td>PM</td>
<td>PDT</td>
</tr>
<tr>
<td>Risk Monitoring and Control</td>
<td>PM</td>
<td>PDT</td>
</tr>
</tbody>
</table>
Risk Methodology (PMI)

- Risk Management Planning
- Risk Identification
- Risk Analysis and Quantification
- Risk Response/Mitigation Plan
- Risk Monitoring and Control
Cost Estimates – What They Mean to You

• Estimates are dependent on **SCOPE**!
• Estimates form the basis for decision-making (expectation management)
• All Civil Works Construction projects requiring authorization **MUST** have estimates certified by Civil Works Cost Dx (NWW)
• Estimates are expected to be as accurate as possible
More on Cost Estimates

“By Public Law 95-269, all construction cost estimates shall be prepared as though the Government were a prudent and well-equipped contractor. Therefore, all costs, which a prudent and experienced contractor would expect to incur, shall be included in the cost estimate.”

Source: ER 1110-2-1302 Civil Works Cost Engineering, 9-15-08
Schedules – What They Mean to You

- Estimates establish schedules, but schedules may also drive estimates.
- Schedules are also dependent on SCOPE!
- Schedules also aid in decision-making (expectation management)
- Schedules are expected to be as accurate as possible
Risk Methodology (PMI)

- Risk Management Planning
- Risk Identification
- Risk Analysis and Quantification
- Risk Response/Mitigation Plan
- Risk Monitoring and Control
Suggested PDT Members

- Project & Planning Managers
- Contracting
- Real Estate & Relocations
- Environmental
- Designers
- Estimators
- Construction
- Operations
- Sponsor(s)
Risk Considerations

- Organizational
- Project Management
- Contract Acquisition
- Technical Risks
- Estimates and Schedules
- Lands and Damages
- Regulatory
- Environmental
- Construction
- External Impacts
PDT to Identify Risk Items

PDT Meets to discuss project scope.

- Cost Engineer explains the Basis of the Government Estimate ("Most Likely Cost").

- The PDT brainstorms potential risk elements.

- The PDT then assigns the “Likelihood” of occurrence.

- The PDT assigns the “Impact” level if occurrence does happen.

- Based on the previous input, risk level events are identified for further action.

<table>
<thead>
<tr>
<th>Risk No.</th>
<th>Risk Event</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Risk Level</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Building Climate – Saturated Local Market</td>
<td>LIKELY</td>
<td>MARGINAL</td>
<td>MODERATE</td>
<td>$3 Billion construction will be going on-in downtown Pittsburgh over the next 5 years.</td>
</tr>
<tr>
<td>2</td>
<td>Volatile Real Estate Values</td>
<td>UNLIKELY</td>
<td>NEGLIGIBLE</td>
<td>LOW</td>
<td>Little to no Real Estate to be purchased</td>
</tr>
<tr>
<td>3</td>
<td>Scope Definition</td>
<td>UNLIKELY</td>
<td>NEGLIGIBLE</td>
<td>LOW</td>
<td>Scope is well defined, there is minimal likelihood of scope increase or changes from the current documents used for estimate development</td>
</tr>
<tr>
<td>4</td>
<td>Scope Growth / Reduction</td>
<td>LIKELY</td>
<td>MARGINAL</td>
<td>MODERATE</td>
<td>Work will be done on the river, unpredictable, scour protection is more vulnerable</td>
</tr>
<tr>
<td>5</td>
<td>Weather</td>
<td>LIKELY</td>
<td>MARGINAL</td>
<td>MODERATE</td>
<td>There are tight delivery windows that will require mitigation efforts if not met.</td>
</tr>
<tr>
<td>6</td>
<td>Schedule Constraints</td>
<td>LIKELY</td>
<td>SIGNIFICANT</td>
<td>HIGH</td>
<td>$3 Billion construction will be going on-in downtown Pittsburgh over the next 5 years.</td>
</tr>
<tr>
<td>7</td>
<td>Equipment Availability/Pricing</td>
<td>LIKELY</td>
<td>MARGINAL</td>
<td>MODERATE</td>
<td>Fuel prices will impact equipment operating costs</td>
</tr>
<tr>
<td>8</td>
<td>Material Availability/Pricing</td>
<td>UNLIKELY</td>
<td>NEGLIGIBLE</td>
<td>LOW</td>
<td>Fuel prices will impact equipment operating costs</td>
</tr>
<tr>
<td>9</td>
<td>Acquisition Plan</td>
<td>LIKELY</td>
<td>SIGNIFICANT</td>
<td>MODERATE</td>
<td>Value Engineering has already been incorporated into the project</td>
</tr>
<tr>
<td>10</td>
<td>Fuel Prices</td>
<td>VERY LIKELY</td>
<td>SIGNIFICANT</td>
<td>HIGH</td>
<td>$2.65 per gallon was used in the Oct 06 MCACES, increases will effect equipment and delivery of materials</td>
</tr>
<tr>
<td>11</td>
<td>Potential savings due to innovation, streamlining, and gains in efficiency</td>
<td>UNLIKELY</td>
<td>NEGLIGIBLE</td>
<td>LOW</td>
<td>The estimate was based on full and open competition, with minimal savings of contractor risks. The Acquisition Plan has not been finalized, therefore there is a potential for additional savings during the contract.</td>
</tr>
<tr>
<td>12</td>
<td>Acquisition Plan</td>
<td>LIKELY</td>
<td>SIGNIFICANT</td>
<td>HIGH</td>
<td>The estimate was based on full and open competition, with minimal savings of contractor risks. The Acquisition Plan has not been finalized, therefore there is a potential for additional savings during the contract.</td>
</tr>
</tbody>
</table>
PDT Benefits – Management Tools

- Highlights Risk Areas
- Highlights Potential Benefits
- Identifies Methods to Manage Risks
- Establishes Platform for Future Risk Studies (the Risk Register)
Risk Methodology (PMI)

- Risk Management Planning
- Risk Identification
  - Risk Analysis and Quantification
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- Risk Monitoring and Control
Results of Crystal Ball Output

• Most Likely Cost Estimate (Risk Based)
• Most Likely Project Schedule (Risk Based)
• Contingency for Total Project Cost Summary
• Sensitivity Analysis
Risk Communication

- Recommended Project contingency and corresponding confidence levels are presented to the PM.

- PM and District Management will decide what confidence level would be acceptable for the project.
### Beyond the Analysis

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>Value</th>
<th>Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>$35,833,239</td>
<td>-10.45%</td>
</tr>
<tr>
<td>10%</td>
<td>$46,442,558</td>
<td>16.06%</td>
</tr>
<tr>
<td>20%</td>
<td>$48,400,180</td>
<td>20.96%</td>
</tr>
<tr>
<td>30%</td>
<td>$49,744,595</td>
<td>24.32%</td>
</tr>
<tr>
<td>40%</td>
<td>$50,988,057</td>
<td>27.42%</td>
</tr>
<tr>
<td>50%</td>
<td>$52,151,692</td>
<td>30.33%</td>
</tr>
<tr>
<td>60%</td>
<td>$53,286,037</td>
<td>33.17%</td>
</tr>
<tr>
<td>70%</td>
<td>$54,462,516</td>
<td>36.11%</td>
</tr>
<tr>
<td><strong>80%</strong></td>
<td><strong>$55,868,598</strong></td>
<td><strong>39.62%</strong></td>
</tr>
<tr>
<td>90%</td>
<td>$57,673,488</td>
<td>44.13%</td>
</tr>
<tr>
<td>100%</td>
<td>$67,240,463</td>
<td>68.04%</td>
</tr>
</tbody>
</table>

Now what?
Risk Methodology (PMI)

- Risk Management Planning
- Risk Identification
- Risk Analysis and Quantification
- Risk Response/Mitigation Plan
- Risk Monitoring and Control
Strategies for Responding to Risks

Negative
- Avoidance
- Transference
- Mitigation

Positive
- Exploit
- Share
- Enhance
Risk Response/Mitigation Efforts

- Risk Responses
  - Acceptance
  - Contingent Response.
- Risk Analysis identifies key risk items.
- Risk Mitigation → Reduces Impact
- Risk Analysis and Response is Iterative.
Risk Response Considerations

• “Secondary risks”: New risks created as a direct result of response to an original risk.
• “Residual risks”: Risks that remain even after response.
• Contingency (either cost or schedule) is a response strategy (but not the only one!).
• Every contingent response should also have an accompanying “fallback” plan (i.e. contingency).
Risk Methodology (PMI)

- Project Delivery Team (within PMP)
- Risk Identification
- Risk Analysis and Quantification
- Risk Response/Mitigation Plan
- Risk Monitoring and Control
That’s great . . . but . . .

What do I do with that, exactly?
Risk Management Made Practical

• Plan for risk – prepare a risk management plan.
• Conduct risk identification meetings – collaborate with the stakeholders (PDT).
• Perform analysis of risks – qualitative and quantitative.
• Communicate the key risks and manage them.
• Plan responses to key risks.
Risk Management Made Practical (cont.)

- Mitigate risk occurrence.
- Consider secondary and residual risks.
- Conduct regular risk review meetings.
- Maintain a risk “watch lists”
- Control your projects appropriate to the risks (i.e. change control).
Conclusion

• Risk management, and risk analysis is not rocket science.
• Risk management and risk analysis principles should be employed in ALL projects.

“An ounce of prevention is worth a pound of cure.”

-Benjamin Franklin
References

- ER 1105-2-100, Planning Guidance Notebook
- ER 1110-1-1300, Cost Engineering Policy and General Requirements
- ER 1110-2-1150, Engineering and Design for Civil Works Projects
- ER 1110-2-1302, Civil Works Cost Engineering
Tools & Information

• National Civil Works Cost Engineering Center
  S/Ed/C/default.htm

• USACE Publications
  http://140.194.76.129/publications/