Project Risk Management: Integrating it in Transportation Projects from Planning through Design and Construction to Minimize Cost and Schedule Overruns

Session 15
Room: C120-122

Tuesday, October 27, 2015
11:00 AM – 11:30 AM

Sagar Khadka, MBP, Fairfax, VA
Tom Hyland, Ohio DOT, Garfield Heights, OH
Presentation Outline

• Perspective (3 min)
• Project Risk Management (PRM) (7 min)
• Implementation of PRM at Cleveland Innerbelt (10 min)
• Quantitative Risk Analysis (6 min)
• Summary (1 min)
• Q & A (3 min)
Perspective

– Construction Projects: On time, within budget?
– Risk Management and Construction Industry
– Experience Background
Construction Projects: On Time, within Budget?

- **A study of 258 transportation infrastructure projects**
  - Completed between 1927 and 1998
  - Five Continents
  - 20 Countries
  - $90 Billion in (1995 prices)

**Findings from Study**
- Cost overruns found in almost 9 out of 10 projects
- Affected projects in all 20 countries

**Schedule Overrun:**
- MBP’s own research from a review of over 2,500 schedules
  ... “did not find instances of cost > 100% and time < 100%!”

Is there a way to identify these risks early on?

Is there a way to avoid/ mitigate them?

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*Bent Flyvbjerg, Mette Skamris Holm, and Søren Buhl
*Journal of the American Planning Association*,
since the 1970’s, extensive literature published on Risk Management

- Technical Papers
- White Papers
- Case Studies
- Best Practice Guides
- Standards of Practice
- Text Books

- Major Conferences (CMAA, AACEI, ASCE, PMI) – dedicated track on Risk Management
Experience Background

On-Going ($5.6B)
- Phase 2 of Cleveland Innerbelt Bridge Project, Cleveland, OH
- Dominion Boulevard Improvement Project, Chesapeake, VA
- Dulles Corridor Metrorail Project (Silver Line), Phase 2, Dulles, VA
- Cannon House Office Building, Washington, DC
- National Air and Space Museum, Smithsonian Institution, Washington, DC
- US Capitol Dome Restoration Project, Washington, DC

Completed ($3.4B)
- Phase 1 of Cleveland Innerbelt Bridge Project, Cleveland, OH
- Customs and Border Protection Project, Washington, D.C.
- National Geospatial-Intelligence Agency, East Campus, Fort Belvoir, VA
- State Department Embassy and Consulate Projects, around the world
- Capitol Visitor Center, Washington, D.C.

Risk Analysis/Management Types & Requirements
- Project Risk Management: On-going Projects
- Cost Risk Analysis
- Schedule Risk Analysis
- Integrated Cost-Schedule Risk Analysis
- Risk Workshops
- Federal Transit Administration (FTA)
- U.S. Government Accountability Office (GAO)
Project Risk Management

- Types of Risk Management
- Risk vs. Issue
- Processes & Tools
- Project Risk Management Model
Types of Risk Management

Traditional Risk Management

- Allocation of Risk via Contract
- Insurance Coverage
- Surety Bonds
- Safety & Accident Prevention Plan
- Warranties
- Dispute Resolution Provisions
- Indemnification Provisions
- Lien Waiver Provisions
- Force Majeure Definition
- Change Order Definition
- Professional Liability ....

Project Risk Management

- Incomplete Design
- Defective Plans & Specification
- Inadequate Site Investigation
- Unrealistic Schedule (Schedule Risk)
- Unrealistic Budget (Cost Risk)
- Supplier’s Ability to Deliver
- Subcontractor’s Ability to Perform
- Utility Coordination
- Permit Requirements
- Public Relations
- Weather, Inflation
- Unforeseen conditions ....
Risk ...

If the locations of existing under-ground utilities are not properly surveyed and marked before starting work in XYZ intersection, there is a risk of hitting the gas line and other utilities, which might result in a delay due to disruption and have a cost impact associated with the repair, replacement and project delay.
Issue

Contractor hits gas line, fire erupts in Lake Worth


A construction worker hit a gas line causing a fiery explosion Tuesday afternoon in Lake Worth. Police said the gas line was cut by a worker on a road grader/mixer in the 3600 block of Shawnee Trail, which
Project risk management is an active and forward looking tool used to:

- identify foreseeable risk events (things that could go wrong) in the project,
- analyze the potential impact of each risk event on the project,
- prioritize risks based on the severity of impact through the use of a Risk Matrix and Risk Register,
- create problem solving strategies in advance to mitigate (recover from) risk impacts, and
- keep an eye on each until the risk event is averted, mitigated, or resolved.
In its simplest form, a potential risk event has three key attributes:

1. **Probability**: Likelihood of risk actually occurring in the project.
   - Unlikely (21 to 40%)
   - Possible (41 to 60%)
   - Likely (61 to 80%)
   - Almost Certain (81 to 100%)

2. **Impact to the cost and/or schedule**.
   - Low
   - Medium
   - High

3. **Time Horizon** (when is the risk event likely to occur?)
   - Near Term
   - Mid Term
   - Long Term
# Master Risk Register (risk prioritization)

<table>
<thead>
<tr>
<th>Clr Code</th>
<th>Status</th>
<th>Id</th>
<th>Title</th>
<th>Meeting Date</th>
<th>Action Officer</th>
<th>Assignee</th>
<th>Time Horizon</th>
<th>Impact</th>
<th>Risk Prob</th>
<th>Strategy</th>
</tr>
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<tbody>
<tr>
<td>Red Alert Risk Items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Near Term</td>
<td>Open</td>
<td>121</td>
<td>Floor Store Installation</td>
<td>8/8/2006</td>
<td>David</td>
<td>Contractor</td>
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<td>High</td>
<td>No of Risk Items in this Category: 4</td>
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<tr>
<td></td>
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<td>18</td>
<td>Schedule Management</td>
<td>8/8/2006</td>
<td>Jim</td>
<td>CM</td>
<td>Near Term</td>
<td>High</td>
<td>90 Monthly schedule reviews</td>
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<tr>
<td>Mid Term</td>
<td>Open</td>
<td>62</td>
<td>Fire Life Safety Test</td>
<td>8/8/2006</td>
<td>Bill</td>
<td>CM</td>
<td>Mid Term</td>
<td>High</td>
<td>90 Preventing Planning</td>
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<tr>
<td></td>
<td>Open</td>
<td>5</td>
<td>Trade Stecking</td>
<td>8/8/2006</td>
<td>David</td>
<td>Contractor</td>
<td>Mid Term</td>
<td>High</td>
<td>80</td>
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<tr>
<td>Yellow Alert Risk Items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Near Term</td>
<td>Open</td>
<td>35</td>
<td>Installation of Security Systems</td>
<td>8/8/2006</td>
<td>Doug</td>
<td>Owner</td>
<td>Near Term</td>
<td>High</td>
<td>No of Risk Items in this Category: 2</td>
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<tr>
<td></td>
<td>Open</td>
<td>3</td>
<td>Manpower</td>
<td>8/8/2006</td>
<td>Ted</td>
<td>Contractor</td>
<td>Near Term</td>
<td>High</td>
<td>50 Monitor manpower</td>
<td></td>
</tr>
<tr>
<td>Mid Term</td>
<td>Open</td>
<td>92</td>
<td>Dust Free Environment in E2</td>
<td>8/1/2006</td>
<td>Gary</td>
<td>CM</td>
<td>Mid Term</td>
<td>High</td>
<td>50 Coordination</td>
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<td>Blue Alert Risk Items</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Near Term</td>
<td>Open</td>
<td>11</td>
<td>Architect’s Special Instructions</td>
<td>7/29/2006</td>
<td>Tim</td>
<td>Designer</td>
<td>Near Term</td>
<td>Medium</td>
<td>50 Review and Prioritize</td>
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<td></td>
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<td>71</td>
<td>Safety</td>
<td>8/1/2006</td>
<td>Ted</td>
<td>Contractor</td>
<td>Near Term</td>
<td>Medium</td>
<td>50 Incentive Program</td>
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<tr>
<td></td>
<td>Open</td>
<td>73</td>
<td>Expansion Space Construction</td>
<td>8/1/2006</td>
<td>Doug</td>
<td>Owner</td>
<td>Near Term</td>
<td>Medium</td>
<td>50</td>
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<tr>
<td></td>
<td>Open</td>
<td>80</td>
<td>Escalator Installation</td>
<td>8/1/2006</td>
<td>John</td>
<td>Contractor</td>
<td>Near Term</td>
<td>Medium</td>
<td>50 Coordination of Manpower</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open</td>
<td>91</td>
<td>Embedded Casework Installation</td>
<td>8/1/2006</td>
<td>Marty</td>
<td>Owner</td>
<td>Near Term</td>
<td>Medium</td>
<td>50 Expedite Shop Drawings</td>
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<tr>
<td></td>
<td>Open</td>
<td>9</td>
<td>Tenant Design Change Requests</td>
<td>8/1/2006</td>
<td>Doug</td>
<td>Owner</td>
<td>Mid Term</td>
<td>Medium</td>
<td>50 Establish task teams</td>
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<tr>
<td></td>
<td>Open</td>
<td>14</td>
<td>Quality Control</td>
<td>8/1/2006</td>
<td>Art</td>
<td>CM</td>
<td>Mid Term</td>
<td>Medium</td>
<td>50 Enforce QC Requirements</td>
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<tr>
<td></td>
<td>Open</td>
<td>45</td>
<td>Training of Operational Personnel</td>
<td>8/1/2006</td>
<td>Carlos</td>
<td>Owner</td>
<td>Mid Term</td>
<td>Medium</td>
<td>50 Joint Presenting and Start up</td>
<td></td>
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</tbody>
</table>

**High Probability, High Impact**

**Low Probability, Medium Impact**
Project Risk Management Model

1. Risk Planning
   - DEFINE
     - Scope
     - Team
     - Strategy

2. Risk Identification
   - IDENTIFY
     - Risk event
     - Impact
     - Probability

3. Risk Analysis
   - ANALYZE
     - Quantitative
     - Qualitative
     - Combination
     - Quantitative
       - Monte Carlo
       - Others
     - Qualitative
       - Risk Register
       - Risk Matrix

4. Risk Response Planning
   - ACTION PLAN
     - Mitigation Plan
     - Action Officer
     - Resolve By
     - Mitigation
       - Transfer
       - Mitigate
       - Accept
       - Avoid
       - Contingency

5. Risk Monitoring & Control
   - RE-ASSESS
     - Weekly
     - Monthly
     - Quarterly
Implementation of PRM at Cleveland Innerbelt Project, Phase 2 (CCG2)

- Built on Phase 1 Success
- Started with Project Risk Workshop
- Master Risk Register
- Individual Risk Report
- Risk Monitoring and Control
- Risk Mitigation Success Stories (Examples)
Implementation of PRM at CCG2

• Built on CCG1 Success
  – Project Risk Management was implemented as value added service by MBP for CCG1
  – Maintained Robust Risk Register
  – Identified and Mitigated a Number of Risks
  – Positive Feedback from All Parties
Implementation of PRM at CCG2

• **Started with Project Risk Workshop**
  – Held on December 10, 2013
  – Participation from Contractor, Designer, ODOT, Consultants
  – Each Participant Asked to Submit “My Top 5 Risks”
  – Over 50 Risks Consolidated and Vetted in Risk Workshop
  – Master Risk Register Generated
  – Attendees: Lead Superintendents, estimators, Lead project engineers, Lead designers, Project Managers for Owner and Contractor
## RISK MANAGEMENT PROGRAM

**CLEVELAND INNERBELT - NEW I-90 EB BRIDGE PROJECT (CCG2)**

**MASTER RISK REGISTER**

**BY SEVERITY**

Status as of October 8, 2015

<table>
<thead>
<tr>
<th>Severity Id</th>
<th>Risk Event</th>
<th>Outcome</th>
<th>Action Officer</th>
<th>Org</th>
<th>Prob</th>
<th>Impact</th>
<th>Mitigation Strategy</th>
<th>Last Update Date</th>
<th>Mitigation Update</th>
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</thead>
<tbody>
<tr>
<td><strong>Red Alert Risk Items</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Near Term</strong></td>
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<tr>
<td></td>
<td>103</td>
<td>Limited GCRTA outage windows</td>
<td>Critical Path Work shutdown until next outage window available</td>
<td>Rob Opel</td>
<td>TGR</td>
<td>65</td>
<td>High</td>
<td>Need early coordination with RTA; adjust construction schedule to their outage</td>
<td>7/6/2015</td>
</tr>
<tr>
<td></td>
<td>107</td>
<td>West slope stabilization/stabilization structure impacts due to unforeseen conditions</td>
<td>Construction activities and excavation of west slope could cause instability issues and/or impacts to stabilization structure.</td>
<td>Tom Hyland</td>
<td>ODOT</td>
<td>65</td>
<td>High</td>
<td>Careful monitoring, proper equipment placement and a thorough water management plan. Prepare potential scenario options for course of action.</td>
<td>1/15/2015</td>
</tr>
<tr>
<td></td>
<td>117</td>
<td>Structural Steel fit up issues during erection</td>
<td>Potential damage to spliced members and/or delays to remedy.</td>
<td>Matt English</td>
<td>TGR</td>
<td>75</td>
<td>High</td>
<td>Working with PDM and fabricator, early field inspection for details and tolerances. Send QC inspector to the shop.</td>
<td>8/10/2015</td>
</tr>
<tr>
<td></td>
<td>149</td>
<td>Span 16 Deck - Repair or Replace?</td>
<td></td>
<td>Tom Hyland</td>
<td>TGR</td>
<td>100</td>
<td>High</td>
<td>Plan for corrective work due today with DBT, IQF and ODOT concurrences</td>
<td>8/10/2015</td>
</tr>
<tr>
<td></td>
<td><strong>Far Term</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>148</td>
<td>Potential shutdown for RNC</td>
<td></td>
<td>Tom Hyland</td>
<td>ODOT</td>
<td>70</td>
<td>High</td>
<td></td>
<td>1/15/2015</td>
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<tr>
<td></td>
<td><strong>Yellow Alert Risk Items</strong></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td><strong>Near Term</strong></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>138</td>
<td>Interferences with CCG1 Project in general.</td>
<td>Delays Work</td>
<td>Tom Hyland</td>
<td>ODOT</td>
<td>75</td>
<td>Medium</td>
<td>Identify a list of activities that are likely to interfere with CCG1. Communicate planned operations with Walsh and ODOT; CCG2 has priority in location.</td>
<td>1/15/2015</td>
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<tr>
<td></td>
<td>140</td>
<td>West slope limited access and interferences with existing tieback structures, walls, piles, etc.</td>
<td>Slow production, possible damages to existing structures</td>
<td>Rob Opel</td>
<td>TGR</td>
<td>50</td>
<td>High</td>
<td>Detailed construction plan of attack. Locate all existing interferences.</td>
<td>7/6/2015</td>
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</tbody>
</table>

**COLOR INDEX**

<table>
<thead>
<tr>
<th>Probability</th>
<th>21 - 40</th>
<th>41 - 60</th>
<th>61 - 80</th>
<th>81 - 100</th>
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<tr>
<td>Impact</td>
<td>Unlikely</td>
<td>Possible</td>
<td>Likely</td>
<td>Almost Certain</td>
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<tr>
<td>Red</td>
<td>High</td>
<td>Med</td>
<td>Low</td>
<td>N/A</td>
</tr>
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</table>

**TIME HORIZON**

Near Term (≈ 90 Days)

Mid Term (≈ 90 - 180 Days)

Far Term (≈ 180 Days)
**RISK MANAGEMENT PROGRAM**  
**CLEVELAND INNERBELT - NEW I90 EB BRIDGE PROJECT**  
**INDIVIDUAL RISK REPORT**  
**TOP 10 RISKS**

<table>
<thead>
<tr>
<th>Risk ID:</th>
<th>140</th>
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</thead>
<tbody>
<tr>
<td><strong>RISK DESCRIPTION</strong></td>
<td>Action Officer: Rob Opel</td>
</tr>
<tr>
<td>West slope limited access and interferences with existing tie back structures, wells, piles, etc.</td>
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<tr>
<td>Slow production, possible damages to existing structures</td>
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<table>
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<tr>
<th><strong>RISK CLASSIFICATION</strong></th>
<th><strong>Status:</strong></th>
<th><strong>Open</strong></th>
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<tr>
<td>Risk Probability:</td>
<td>Category:</td>
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<tr>
<td>Impact:</td>
<td>Assigned to:</td>
<td>TGR</td>
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<tr>
<td>Time Frame:</td>
<td>Date Identified:</td>
<td>12/10/2013</td>
</tr>
<tr>
<td>Risk Identified by:</td>
<td>Date Last Updated:</td>
<td>7/6/2015</td>
</tr>
<tr>
<td>Adam</td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>RISK MITIGATION STRATEGY</strong></th>
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<tr>
<td>Mitigation:</td>
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<tr>
<td>Detailed construction plan of attack. Locate all existing interferences.</td>
<td></td>
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**MONTHLY RISK ASSESSMENT HISTORY**

<table>
<thead>
<tr>
<th>Date</th>
<th>Update Notes</th>
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</thead>
<tbody>
<tr>
<td>12/10/2013</td>
<td>Risk identified and discussed during the first risk workshop held on 12/10/2013.</td>
</tr>
<tr>
<td>1/28/2014</td>
<td>Started coordinating this risk through the weekly Viaduct Task Force. West slope added to the standing agenda with Rob Opel as leading the coordination of this effort in the Task Force.</td>
</tr>
<tr>
<td>2/5/2014</td>
<td>West slope access coordinated through Geotech task force</td>
</tr>
<tr>
<td>4/10/2014</td>
<td>Address Fay access to run over tie backs with excavator.</td>
</tr>
<tr>
<td>6/4/2014</td>
<td>Plans are continuing to be being developed to address construction access requirements within the west slope.</td>
</tr>
<tr>
<td>8/4/2014</td>
<td>Final disposition: TGR monitoring slope and existing structures during construction</td>
</tr>
<tr>
<td>5/4/2015</td>
<td>All Drilled shafts in place; some concerns, but no impacts to the structures to date; Dockwall next.</td>
</tr>
<tr>
<td>7/6/2015</td>
<td>Drilled Shafts and Pier 4 Bulkhead complete. Continue to monitor Instrumentation and SWPPP controls as excavation activities resume</td>
</tr>
</tbody>
</table>
Implementation of PRM at CCG2

- **Risk Monitoring and Control**
  - Follow on Project Risk Workshops
  - Part of Agenda in Bi-Weekly CCG2 Progress Meetings
  - Monthly Updates on Risks and Risk Mitigation Strategies
    - Monthly Input from Action Officers
    - Update Fed into Risk Database
    - New Monthly Reports Generated and Shared Among Parties
    - Keep Project team aware of identified risks
    - New risks added, as they become evident: (Risk ID: 0148 -- Potential shutdown of CCG2 due to Republican Nation Convention in July 2016)
Implementation of PRM at CCG2

• Risk Mitigation Success Stories

  – Risk ID: 0146  **Steel Delivery access issues – Valley area**
    o Contractor identified
    o Impacts Substantial Completion Date

  – RISK ID: 0117  **Structural Steel fit up issues during erection**
    o ODOT identified
    o Potential damage to spliced members and/or delays to remedy

  – Risk ID: 0139  **Responding to Scope Modifications**
    o ODOT and Contractor mutually identified
    o Distracts from Critical Activity Focus and Schedules
Quantitative Risk Analysis

• Schedule Risk Analysis
  • Why do construction projects rarely finish on time?

• Cost Risk Analysis
  – Why do projects almost always overrun the budget?

Brief discussion on “why” by way of Schedule Risk Analysis
**CPM Schedule:** A day of slippage on any of the *Longest Path* activities will delay the project completion date by a day.
Any number of factors could influence the duration of concrete work

- Formwork
- Rebar
- Concrete batch
- Concrete delivery
- Inadequate labor
- Rain
- Heat
- Access

Given above factors, are we still absolutely certain about about 35 days?
Given the possibility that any number of factors (formwork, rebar, concrete batch, concrete delivery, access to jobsite, labor availability, rain, heat, predecessor activities, etc.) could become real issue when construction begins, we can no longer be certain that the concrete work will be competed in precisely 35 day.

What would be a reasonable duration then?

- 40?
- 45?
- Even 30?
- Who knows for sure?
**Schedule Risk Analysis**

**Quantitative Risk Analysis**

**Deterministic Duration**

35 Days

30 Days (min) 50 Days (max)

Minimum, Most Likely, Maximum Duration
### Schedule Risk Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Remaining Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Total Float</th>
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<tbody>
<tr>
<td>Minimum</td>
<td>Most Likely</td>
<td>Maximum</td>
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<td><strong>Contract Milestones</strong></td>
<td>458</td>
<td>A01-Jul-12</td>
<td>01-Jul-14</td>
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<td><strong>Prepare and Submit</strong></td>
<td>187</td>
<td>A10-Jul-12</td>
<td>03-Oct-13</td>
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<td><strong>Review and Approve</strong></td>
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<td>A19-Jul-12</td>
<td>31-Oct-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Review and Approve - Coordination Drawings Penthouse</strong></td>
<td>15</td>
<td>10-Apr-13</td>
<td>30-Apr-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Fab and Deliver</strong></td>
<td>159</td>
<td>A07-Sep-12</td>
<td>05-Sep-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>F&amp;D Ductwork</strong></td>
<td>30</td>
<td>01-May-13</td>
<td>11-Jun-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Foundation/Vertical Structure</strong></td>
<td>304</td>
<td>A05-Sep-12</td>
<td>28-Jan-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Building Enclosure</strong></td>
<td>156</td>
<td>25-Jun-13</td>
<td>27-Nov-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Interior Rough-In</strong></td>
<td>252</td>
<td>15-May-13</td>
<td>21-Jan-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Duct Mains Base Building - Lower Level</strong></td>
<td>15</td>
<td>12-Jun-13</td>
<td>02-Jul-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Duct Mains Base Building - Level 1</strong></td>
<td>15</td>
<td>03-Jul-13</td>
<td>23-Jul-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Mechanical Systems</strong></td>
<td>342</td>
<td>26-Jun-13</td>
<td>02-Jun-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Install Vertical Ductwork &amp; Shafts</strong></td>
<td>20</td>
<td>03-Dec-13</td>
<td>31-Dec-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Install Water Distribution System Valves &amp; BF Preventor</strong></td>
<td>15</td>
<td>30-Oct-13</td>
<td>19-Nov-13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Interior Finishes</strong></td>
<td>380</td>
<td>A12-Nov-12</td>
<td>28-May-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Hang &amp; Finish GMB Lower Level - East Side</strong></td>
<td>15</td>
<td>28-Nov-13</td>
<td>18-Dec-13</td>
<td>22</td>
</tr>
<tr>
<td><strong>Hang &amp; Finish GMB 1st Floor - East Side</strong></td>
<td>15</td>
<td>12-Dec-13</td>
<td>01-Jan-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Partitions 1st Level - East Side</strong></td>
<td>12</td>
<td>02-Jan-14</td>
<td>22-Jan-14</td>
<td>0</td>
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<tr>
<td><strong>Install furnishings and applied finishes - 1st Level</strong></td>
<td>20</td>
<td>20-Feb-14</td>
<td>19-Mar-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Install furnishings and applied finishes - 2nd Level</strong></td>
<td>20</td>
<td>20-Mar-14</td>
<td>16-Apr-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Install furnishings and applied finishes - 3rd Level</strong></td>
<td>20</td>
<td>17-Apr-14</td>
<td>14-May-14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Install Terrazzo 1st Level</strong></td>
<td>20</td>
<td>23-Jan-14</td>
<td>19-Feb-14</td>
<td>0</td>
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<tr>
<td><strong>Install furnishings and applied finishes - 4th Level</strong></td>
<td>20</td>
<td>01-May-14</td>
<td>28-May-14</td>
<td>6</td>
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<tr>
<td><strong>Install furnishings and applied finishes - Tenant 1st Level</strong></td>
<td>20</td>
<td>20-Feb-14</td>
<td>19-Mar-14</td>
<td>0</td>
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<tr>
<td><strong>Install furnishings and applied finishes - Tenant 2nd Level</strong></td>
<td>20</td>
<td>20-Mar-14</td>
<td>16-Apr-14</td>
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<tr>
<td><strong>Install furnishings and applied finishes - Tenant 3rd Level</strong></td>
<td>20</td>
<td>17-Apr-14</td>
<td>14-May-14</td>
<td>0</td>
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<tr>
<td><strong>Inspection, Turnover and Closeout</strong></td>
<td>120</td>
<td>03-Mar-14</td>
<td>30-Jun-14</td>
<td>1</td>
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<tr>
<td><strong>Clean and Punch Building</strong></td>
<td>25</td>
<td>15-May-14</td>
<td>19-Jun-14</td>
<td>0</td>
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<tr>
<td><strong>Building Final Inspections</strong></td>
<td>22</td>
<td>30-May-14</td>
<td>30-Jun-14</td>
<td>0</td>
</tr>
</tbody>
</table>
Schedule Risk Analysis

Quantitative Risk Analysis

Simulation Run 5,000 Times

- Probability of completing by June 30, 2014 = 0%
- 80% Confidence Date = August 19, 2014
Summary

• Integration of Project Risk Management Tools
  – Planning
  – Design
  – Construction

• Quantitative Risk Analysis
  – Schedule Risk Analysis: Will my project complete on time?
  – Cost Risk Analysis: Will I be able to stay within budget?

• On-going “Project Risk Management” by Project Team
  – Plan, identify, analyze, monitor and mitigate risks
  – Prioritize and allocate resource where it is needed most
  – Relatively tiny effort and cost on a major project, compared to the cost of an ad hoc reaction

Tools

Project Risk Management

- Incomplete Design
- Defective Plans & Specification
- Inadequate Site Investigation
- Unrealistic Schedule, Budget
- Unforeseen conditions ....

Schedule Risk Analysis

Risk Register & on-going Project Risk Management

Cost Risk Analysis
Questions?

Risks are inherent in construction projects

I’m sure glad the hole isn’t in our end.

Thank you!