CPM, PERT & Schedule Risk Analysis in Construction

Pedram Daneshmand
MConstMgmt, MEngSc, BEng (Civil)
MIEAust
Introduction

- Program Risk Management System
- System Safety Analysis
- Uncertainty Quantification
- Objective: Quantification / Presentation of Time required to achieve a business objective
- Techniques for Schedule Analysis in Construction
  - CPM (CPA), PERT, Monte Carlo Simulation Method
- Construction Feasibility Management Case Study
Program Risk Management System
System Safety Analysis

• FMEA: Failure Modes and Effects Analysis is a methodology for analyzing potential reliability problems early in the development cycle when it is easier to take actions to overcome these issues, thereby enhancing reliability through design.

• Accident Frequency Assessment

• System Reliability Analysis

• Human Reliability

• *Uncertainty Quantification*
Uncertainty Analysis Approaches

- Decision Trees
- Linear Programming
- Line of Balance
- PERT
  - *Monte Carlo Simulation Method*
Monte Carlo Simulation Advantages

- Examine more than one Critical Path (CPM)
- Accurate
  - Overall Duration Distribution
  - Confidence Interval (Accuracy Range)
- Opportunity for Sensitivity Analysis
- Varied Activity Distribution Types – Not just Beta
- Schedule logic can include branching: Probabilistic and Conditional
- If resources loaded, analysis integrates schedule and cost.
Monte Carlo Simulation Outputs

- **Tabular Statistical Data**
  - Activity listings showing:
    - Start & Finish Date Ranges
    - Duration Ranges
    - Number of times and/or percent Critical
    - Criticality Distribution Profile
    - Major Critical Path reports
  - Three point estimates typically mark out the range of outcomes from the 5th to the 95th percentiles. If estimates are accurate, then only 5% of the activities or risk events should fall beyond the pessimistic points.
Feasibility Management Case Study

• Case Study:
  - *Building Engineering Services Feasibility Studies on various Telephone Exchanges* included:
    • Identify non-compliance with client’s Fire Safety Manual
    • Identify non-compliance with client’s standards
    • Identify available capacity
    • Identify Critical Elements in services
    • Increase system reliability and availability
CPM and PERT Methods

- CPM: Likely task Durations
- PERT: Optimistic, Likely and Pessimistic Durations

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Baseline Start</th>
<th>Baseline Finish</th>
<th>Min</th>
<th>Likely</th>
<th>Max</th>
<th>PERT</th>
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<tbody>
<tr>
<td>1</td>
<td>Telephone Exchange Feasibility</td>
<td>Mon 13/09/04</td>
<td>Mon 29/11/04</td>
<td>29</td>
<td>56</td>
<td>98</td>
<td>58</td>
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<td>2</td>
<td>Project Released</td>
<td>Mon 13/09/04</td>
<td>Mon 13/09/04</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>3</td>
<td>Develop Feasibility PDP</td>
<td>Mon 13/09/04</td>
<td>Tue 21/09/04</td>
<td>2</td>
<td>7</td>
<td>20</td>
<td>8</td>
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<tr>
<td>4</td>
<td>Prepare Feasibility RFT</td>
<td>Wed 22/09/04</td>
<td>Tue 12/10/04</td>
<td>4</td>
<td>15</td>
<td>30</td>
<td>16</td>
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<td>5</td>
<td>Feasibility RFT Issued</td>
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<td>5</td>
<td>7</td>
<td>10</td>
<td>8</td>
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<tr>
<td>7</td>
<td>Tender Review / Stakeholder Review</td>
<td>Wed 22/10/04</td>
<td>Thu 28/10/04</td>
<td>5 days</td>
<td>7 days</td>
<td>10 days</td>
<td>7 days</td>
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<td>Feasibility RFT Award</td>
<td>Thu 28/10/04</td>
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<td>9</td>
<td>Site Inspection</td>
<td>Fri 29/10/04</td>
<td>Tue 23/11/04</td>
<td>10</td>
<td>18</td>
<td>20</td>
<td>17</td>
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<td>10</td>
<td>Stakeholder Brief of Key Findings</td>
<td>Wed 24/11/04</td>
<td>Wed 24/11/04</td>
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<td>1</td>
<td>3</td>
<td>1</td>
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<td>11</td>
<td>Complete Report</td>
<td>Thu 25/11/04</td>
<td>Fri 26/11/04</td>
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<td>2</td>
<td>4</td>
<td>2</td>
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<td>12</td>
<td>Issue Final Report</td>
<td>Mon 29/11/04</td>
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<td>Practical Completion Date (PC)</td>
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- Schedule MSP layout based on CPM & PERT
Schedule Risk Analysis Methodology

- Definition of Project Identifications
- Risk Definition
- Create CPM and/or PERT Output
- Uncertainty Estimation
- Schedule Risk Analysis Performance (Monte Carlo Simulation)
- Sensitivity Risk Analysis Performance
- Assumptions Re-consideration
Outputs

**Subject Telephone Exchange**

**Entire Plan: Finish Date**

<table>
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<tr>
<th>Analysis</th>
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<tr>
<td>Simulation: Latin Hypercube</td>
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<td>Iterations: 1000</td>
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<table>
<thead>
<tr>
<th>Convergence</th>
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<tbody>
<tr>
<td>Plan Finish Date: Converged in 200 iterations (variation &lt; 1% over 100 iterations)</td>
</tr>
<tr>
<td>Total Plan Cost: Converged in 200 iterations (variation &lt; 1% over 100 iterations)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistics</th>
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<tbody>
<tr>
<td>Minimum: 02/Nov/04</td>
</tr>
<tr>
<td>Maximum: 11/Jan/05</td>
</tr>
<tr>
<td>Mean: 05/Dec/04</td>
</tr>
<tr>
<td>Max Hits: 140</td>
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<tr>
<td>Standard Deviation: 11.56</td>
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<tr>
<td>Selected Confidence: 80%</td>
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<tr>
<td>Deterministic Finish: 29/Nov/04</td>
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<tr>
<td>Probability: 30%</td>
</tr>
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**Cumulative Frequency**

- 100% 11/Jan/05
- 95% 23/Dec/04
- 90% 21/Dec/04
- 85% 16/Dec/04
- 80% 15/Dec/04
- 75% 14/Dec/04
- 70% 10/Dec/04
- 65% 09/Dec/04
- 60% 08/Dec/04
- 55% 07/Dec/04
- 50% 06/Dec/04
- 45% 03/Dec/04
- 40% 02/Dec/04
- 35% 01/Dec/04
- 30% 29/Nov/04
- 25% 26/Nov/04
- 20% 25/Nov/04
- 15% 24/Nov/04
- 10% 22/Nov/04
- 5% 17/Nov/04
- 0% 02/Nov/04

**Distribution (start of interval)**

- 02/Nov/04
- 19/Nov/04
- 06/Dec/04
- 23/Dec/04
- 09/Jan/05
Conclusion/Suggestions

- We reached 140 Max Hits when Std Deviation was 11.56 and Min and Max PPC Dates were 02/Nov/04 and 11/Jan/05 respectively.
- Deterministic Finish Probability for PPC is just 30%.
- PERT Finish Probability for PPC is about 35%.
- Schedule Risk Analysis suggests the 80% probability for PPC Date.
- Output illustrates the probability of different PPC Dates.
- Project modeled with Triangle Distribution. Beta Pert Distribution can be considered for future analysis.
- Analyze similar to Cost Risk Analysis.
- Duration Sensitivity Risk Analysis should support the data.
- Further study into the Confidence Levels is required.
More Risks ... More Achievements
Less Risks ... More Safety

*Answer*: *Risk Management.*