Uncertainty-based Estimating: Transportation Risk and Uncertainty Evaluation (TRUE)

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Scope of Presentation

- Why is estimating such a problem for the Transportation Industry?
- Reducing project risk requires understanding project uncertainties.
- Principles of a risk-based approach.
- Methods for reducing project risk.
- Success within the Transportation Industry.
The Poster Child Example

Boston Central Artery
1985-2005, $2.5 to $16 billion

- Cost may turn out to be <600% of the initial projections
- Professional reputations and careers have been lost
- Criminal prosecution
- A major “black eye” for the civil design and construction industry
- Not over yet
NRC Study and Report


COMPLETING THE “BIG DIG” - Managing the Final Stages of Boston’s Central Artery/Tunnel Project

 Authored by: Seven-person Committee to Review Project management Practices
Evolution of Cost for Boston Central Artery and Tunnel

"BIG DIG" Cost Estimate

![Graph showing the evolution of cost for Boston Central Artery and Tunnel with multiple bars representing different years and cost components.](image)

- **Million Dollars**
- **Year:** 85, 87, 89, 91, 92, 94, 00, 01, 02
- **Legend:**
  - Inflation
  - Change in Scope, Schedule, Pricing
  - Original Scope
Flyvbjerg Study of 258 Projects

Conclusions:

Final cost: about TWICE the initial estimate

The average overrun: > 20% compared with Engineer’s Estimate

90% of cost estimates: low

This has been a problem: 70 years
Is the Problem Linked to how DOT’s Prepare Estimates?

Planning
- Judgment/Experience
- Historic Comparisons (lane-mile)
- Parametric
- Trans*port TRACER

Programming

Preliminary Design
- Cost plus Contingency

Final Design
- Deterministic Engineers Estimate

A/B/A

Construct
- Detailed Estimates vs. Historic Bid Averages
- Contingencies between 5% to 100% are added

Trans*port CES
Other Professions Recognize the Role of Uncertainty in Estimating

<table>
<thead>
<tr>
<th>Estimate Class</th>
<th>Level of Project Definition</th>
<th>Purpose of the Estimate</th>
<th>Estimating Methodology</th>
<th>Expected Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 5</td>
<td>0 to 2%</td>
<td>Screening or Feasibility</td>
<td>Judgment or Stochastic</td>
<td>+100 to -50</td>
</tr>
<tr>
<td>Class 4</td>
<td>1% to 15%</td>
<td>Conceptual Studies or Feasibility</td>
<td>Primarily Stochastic</td>
<td>+75 to -40</td>
</tr>
<tr>
<td>Class 3</td>
<td>10% to 40%</td>
<td>Budget Authorization Design (Control)</td>
<td>Mixed, but Primarily Stochastic</td>
<td>+40 to -20</td>
</tr>
<tr>
<td>Class 2</td>
<td>30% to 705</td>
<td>Design or Bid/Tender</td>
<td>Primarily Deterministic</td>
<td>+20 to -10</td>
</tr>
<tr>
<td>Class 1</td>
<td>50% to 100%</td>
<td>Check Estimate or Bid/Tender</td>
<td>Deterministic</td>
<td>+10 to -5</td>
</tr>
</tbody>
</table>

Adapted from Association for the Advancement of Cost Engineering International by Anderson (2003)
The Evolving Policy to Recognize Risk

- US Department of Transportation - Policy Directives
- FHWA
  - TRB/FHWA/ASSHTO/ NCHRP Task Force
  - 10-State Demonstration Project
  - NHI Training Programs
  - NCHRP Project 8-49
- FTA
  - Policy requires risk-based assessment for funding (8/03)
  - PMOG #22
  - NCHRP 20-7
- Other Federal State and Provincial Agencies
- High visibility within the Professional Community
Professional Studies that Recognize Risk

• NCHRP 20-7, Task 152
  “Best Practices and Guidelines for Project Cost Estimating”  
  2002

• NCHRP 8-49
  “Procedures for Cost Estimation and Management for Highway Projects During Planning, Programming and Pre-construction”  
  2004

• NCHRP/TCRP G-07
  “Managing Capital Costs of Major Federally Funded Surface Transportation Infrastructure”  
  2003

• AASHTO Task Force on Cost Estimating w/20 State DOT’s Participating  
  2004
Estimating Management Approach

- Planning
- Programming
- Preliminary Design
- Final Design
- A/B/A
- Construct

- Deterministic Estimating w/ Contingencies
- Listed Uncertainties
- Risk-based Estimating and Risk Management
- Explicit Risk Assessment
- Risk Management and Cost Containment
TRUE - A Risk-based Approach

- Replace traditional contingency with explicitly identified and quantified risks (and opportunities)
- Characterize the risks in terms of consequences and likelihoods (probabilities)
- Use a structured approach to separate the estimate into consistent “base” and “risk” components. Focus on the risks (uncertainties)
- Present results that are useful to the Project Team and Managers
Underlying Characteristics of Risk-based Methods

- There are different kinds of uncertainty encountered during development of a project (policy risk to technical risk to management risk)
- Uncertainty can be described with best available information - either/both Objective or Subjective
- The appropriate contingency, and the underlying range of uncertainty, usually decrease during the development of a project
- These principles can be incorporated in project evaluation and risk management
An Estimate Captures Different Kinds of Information

- **Unrecognized Cost**
- **Known but Not Quantified**
- **Known and Quantifiable** (can include small uncertainty)

**Total Cost**

**Conservative Estimate** - with Allowance

**Contingency**

**Estimate at any point in time**

Project Plan & Concept

30% Design

100% Design

Construction Completion

Percentage of Project Cost

Project Development (Time)
Important Uncertainties Vary with Stage of the Project Development

• Conceptual/Planning/Early Stage
  - Governance/Administrative Ambiguity/Authorization
  - Environmental Process/Permits
  - Real Estate/ROW
  - Financing Plans/Commitments

• Early to Final Design
  - Technical Issues (structural, geotechnical, contamination, utilities...)
  - Scope
  - Construction/Constructability, MOT

• Final Design/Construction
  - Expectations for the Project, Consequences of Delays
  - Financing Plan/Schedule
  - Contracting, Disputes, Multi-party Interfaces
  - Construction Responsibilities
Where Uncertainties (Risks) Need to be Resolved

Planning | Programming | Preliminary Design | Final Design | A/B/A | Construct

Environment | Geotechnical | Contracts
Right of Way | Structures | Insurance/Bonds
Governance/Stakeholders | Pavements | Construction
Financing | Hydraulics | Methods
Civil & Environmental Justice | Stormwater | MOT
Multi-modal Systems | Tunnels | Market Conditions
Teaming | Intelligent Transportation | Disputes
Options/Alternatives | Permitting | Weather

SCOPE

Contracts
Insurance/Bonds
Construction
Methods
MOT
Market Conditions
Disputes
Weather
Security
As a Design Evolves Uncertainty Decreases

Ultimate cost (or schedule)

Estimate

Reduce scope or Risk Management?

Significant problems confirmed

Few problems confirmed

Range of Initial Estimate

1% 5% 30% design level
Principles of the TRUE Approach

- Work closely (constructively) with the Project Team
- Balance the Project Team bias with independent Subject Matter Experts
- Separate estimates into the Base and Risk components to focus on uncertainty
- Define risks (uncertainties) at the basic or disaggregated level to the extent possible (no contingencies)
- Apply broad flexibility to represent uncertainty and correlation with objective and subjective input
- Simulation allows for analysis of complex situations
- Present results in terms of ranges and/or distributions
- Use of integrated applications such as risk management
Typically done in a workshop setting that includes:

- Project Team
- Risk Evaluation Team
  - Base assessment
  - Risk assessment
  - Modeling
RISK Register

- Identify all (<100) potential problems and opportunities that could lead to significant changes in activity costs and/or durations

<table>
<thead>
<tr>
<th>Challenge to EIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Seismic Design Criteria</td>
</tr>
<tr>
<td>Unit Cost for Steel</td>
</tr>
</tbody>
</table>
## Example: Risk Registry & Risk Factor Assessments

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Risk or Opportunity</th>
<th>Affected Project Activities</th>
<th>Probability of Occurrence</th>
<th>Cost Change ($M)</th>
<th>Duration Change (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Need more underpinning / soil stabilization</td>
<td>40a</td>
<td>30%</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Unknown utilities discovered</td>
<td>37</td>
<td>70%</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Must keep Penn and Liberty St open</td>
<td>32</td>
<td>15%</td>
<td>0.0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>More staging area required</td>
<td>32</td>
<td>70%</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Termination not allowed for 2 years</td>
<td>35</td>
<td>5%</td>
<td>5.0</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Route 65 underpinning</td>
<td>29</td>
<td>50%</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>58</td>
<td>Systems Integration and Testing</td>
<td>40</td>
<td>40%</td>
<td>0.30</td>
<td>0</td>
</tr>
<tr>
<td>59</td>
<td>Right of Way, Acquisition Schedule</td>
<td>65</td>
<td>80%</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>60</td>
<td>Force Majeure (other than defined elsewhere)</td>
<td>23</td>
<td>50%</td>
<td>0.30</td>
<td>6</td>
</tr>
<tr>
<td>61</td>
<td>Archaeological/Historical/Cultural finds</td>
<td>40</td>
<td>50%</td>
<td>0.20</td>
<td>0.5</td>
</tr>
<tr>
<td>62</td>
<td>Unanticipated contamination (soil or GW) in excavations</td>
<td>Indep to 29, 32</td>
<td>50%</td>
<td>1.00</td>
<td>0</td>
</tr>
<tr>
<td>63</td>
<td>Geotechnical Instrumentation for Tunneling</td>
<td>Split between 29 and 55</td>
<td>100%</td>
<td>0.75</td>
<td>0</td>
</tr>
</tbody>
</table>
Characterize RISK

For each problem and opportunity, quantify:

**Consequences** (changes in cost or duration if it occurs)

**Likelihood of occurrence**

<table>
<thead>
<tr>
<th>Event</th>
<th>Consequences</th>
<th>Likelihood (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIS Challenge</td>
<td>0.5 to A</td>
<td>6 to A</td>
</tr>
<tr>
<td>Seismic Criteria</td>
<td>1.0 to C</td>
<td>2 to B and C</td>
</tr>
<tr>
<td>Steel</td>
<td>6% of CN</td>
<td>0</td>
</tr>
</tbody>
</table>

Plan and flow chart

Assess Activity

Base Costs, Durations, and
Escalation Rates

Develop Cost and Schedule

Uncertainty Model

Develop Risk Registry

Assess Risk Inputs

Evaluate Uncertainty and Sensitivity in Cost and Schedule

Identify and Evaluate Risk-Management Strategies and Other Applications

Report Results

Update (optional)
Evaluate Uncertainty in Total Project Cost and Duration

- Define each Activity “Base” Cost
- Define each Activity “Base” Duration
- Risk Events (likelihood of occurrence, and likelihood for cost and duration changes if the event occurs)
Results & Deliverables

RICH SOURCE OF INFORMATION

Cost Risk Contribution By Item

<table>
<thead>
<tr>
<th>Risk Rank</th>
<th>Contribution to Expected Cost Risk</th>
<th>Risk Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Current $M</td>
</tr>
<tr>
<td>1</td>
<td>14.9%</td>
<td>6.6</td>
</tr>
<tr>
<td>2</td>
<td>9.0%</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>9.0%</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>8.5%</td>
<td>3.8</td>
</tr>
<tr>
<td>5</td>
<td>6.7%</td>
<td>2.9</td>
</tr>
<tr>
<td>6</td>
<td>4.4%</td>
<td>2.0</td>
</tr>
<tr>
<td>7</td>
<td>3.4%</td>
<td>1.5</td>
</tr>
<tr>
<td>8</td>
<td>3.4%</td>
<td>1.5</td>
</tr>
<tr>
<td>9</td>
<td>2.7%</td>
<td>1.2</td>
</tr>
<tr>
<td>10</td>
<td>2.3%</td>
<td>1.0</td>
</tr>
<tr>
<td>11</td>
<td>1.8%</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Quantified risk registry can feed & focus VE & Risk Management
also:
• uncertainty in escalated cost
• prioritized list of delay risks
• prioritized list of activities (for VE)
• effectiveness of risk management
• chance of meeting milestones
• cash flow
## Example Results - Cost Risk Ranking

<table>
<thead>
<tr>
<th>Risk Rank</th>
<th>Contribution to Expected Cost Risk</th>
<th>Risk Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.9% 6.6</td>
<td>43. Additional cost for Vehicles due to decision delay</td>
</tr>
<tr>
<td>2</td>
<td>9.0% 4.0</td>
<td>50. Dispute Resolution and Litigation (other than listed separately)</td>
</tr>
<tr>
<td>3</td>
<td>9.0% 4.0</td>
<td>49. Clarity of Contract Documents</td>
</tr>
<tr>
<td>4</td>
<td>8.5% 3.8</td>
<td>55. Cashflow and debt-service cost (5% on $100M)</td>
</tr>
<tr>
<td>5</td>
<td>6.7% 2.9</td>
<td>Aggregate Identified Minor Risks (or Opportunities)</td>
</tr>
<tr>
<td>6</td>
<td>4.4% 2.0</td>
<td>Unidentified Risks</td>
</tr>
<tr>
<td>7</td>
<td>3.4% 1.5</td>
<td>63. Geotechnical Instrumentation (ECIS) for Tunneling</td>
</tr>
<tr>
<td>8</td>
<td>3.4% 1.5</td>
<td>45. Utilities, Cost sharing at 50:50 may change</td>
</tr>
<tr>
<td>9</td>
<td>2.7% 1.2</td>
<td>23. Ground Control (grouting, etc.) (tunnel)</td>
</tr>
<tr>
<td>10</td>
<td>2.3% 1.0</td>
<td>64. Maintenance and Protection of Traffic</td>
</tr>
<tr>
<td>11</td>
<td>1.8% 0.8</td>
<td>54. Delay reaching FFGA</td>
</tr>
</tbody>
</table>

Similar for Opportunities
Example Results - Duration Risk Ranking

<table>
<thead>
<tr>
<th>Risk Rank</th>
<th>Contribution to Expected Time Risk$^1$ (Months)</th>
<th>Risk Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.5</td>
<td>47. Schedule uncertainties related to existing utilities (other than listed separately)</td>
</tr>
<tr>
<td>2</td>
<td>4.0</td>
<td>54. Delay reaching FFGA</td>
</tr>
<tr>
<td>3</td>
<td>3.0</td>
<td>51. Interface &amp; Coordination among contractors (excludes Systems)</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>Aggregate Identified Minor Risks (or Opportunities)</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>20. Lead time on machine (TBM)</td>
</tr>
<tr>
<td>6</td>
<td>0.8</td>
<td>58. Systems Integration and Testing/Start Up Issues</td>
</tr>
<tr>
<td>7</td>
<td>0.8</td>
<td>Unidentified Risks</td>
</tr>
<tr>
<td>8</td>
<td>0.5</td>
<td>22. Machine goes off line &amp; grade (TBM)</td>
</tr>
<tr>
<td>9</td>
<td>0.5</td>
<td>3. Need to keep both Penn and Liberty open at once (Gateway Station)</td>
</tr>
<tr>
<td>10</td>
<td>0.4</td>
<td>9. Unknown Utilities (North Shore)</td>
</tr>
<tr>
<td>11</td>
<td>0.4</td>
<td>24. Obstruction - launch and retrieval pits (TBM)</td>
</tr>
</tbody>
</table>

**Similar forOpportunities**

Note 1. Not necessarily on critical path; can be identified with additional effort.
Risk Management Process

- Using the risk assessment characterization, target those issues where there is potential for mitigation.
- Identify potential risk management actions.
- Critically evaluate the potential for change in the risk if mitigation actions are successful.
- Critically evaluate the likelihood of successfully implementing risk mitigation actions.
- Assess the cost for risk mitigation.
Risk Management Process (cont.)

- Screen Potential Risk Management actions for effectiveness
- Collect a coherent set of risk management actions into one or more risk management plans
-Probabilistic modeling (simulation)
- Implement
Value Engineering

- Similar to and/or different from Risk Management?

- Usually Risk Management (definition) precludes scope changes

- Value Engineering: “is an organized application of common sense and technical knowledge directed at finding and eliminating unnecessary costs in a project”  
  
  *FHWA (2003)*

- Value Engineering has many elements, such as, team work, functional analysis, creativity, cost-worth, and the systematic application of a recognized technique
## Example of Risk Mitigation Element

<table>
<thead>
<tr>
<th>Risk Mitigation Element</th>
<th>Probability</th>
<th>Impact</th>
<th>Cost</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller Building contamination (now in Base)</td>
<td>1.0</td>
<td>0</td>
<td>10%</td>
<td>26</td>
</tr>
<tr>
<td>Retaining walls (now MSE walls, now in Base)</td>
<td>0.35</td>
<td>0</td>
<td>0%</td>
<td>26</td>
</tr>
<tr>
<td>Coordination with Carnegie Science Center - Miller Bldg</td>
<td>1.0</td>
<td>0</td>
<td>85%</td>
<td>26</td>
</tr>
</tbody>
</table>

Cost of building and demolition costs are uncertain. Base assumes full take, demolition, and business relocation. However, full vs. partial take issue is still not resolved (not accounted for in risk assessment; included under mitigation). Base includes $4.5M for property and $1M for demolition.

### Mitigation actions:
- There are three options: a) current plan is implemented; b) current plan plus risk, c) alternative for partial replacement. Option c) would involve reconstruction of building for owner (CSC) and would require partial demolition and removal of existing building and replacement with new addition on other side of building. Would reduce take to 1/3 of full, but adds cost to implement. Could be a net opportunity relative to the base (outcome “c” to right). Plan needs to be coordinated with (and sold to) owner.

<table>
<thead>
<tr>
<th>Replace with:</th>
<th>a. 0 (base is valid)</th>
<th>b. 1.0 (original risk)</th>
<th>c. -2.0 (net savings relative to base)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>a. 5%</td>
<td>b. 50%</td>
<td>c. 45%</td>
</tr>
</tbody>
</table>

### Note 1.
Not necessarily on critical path; can be identified with additional effort.
### Example Risk Management Plan

<table>
<thead>
<tr>
<th>Issue</th>
<th>Current Risk</th>
<th>Revised Risk</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Likelihood</td>
<td>Consequence</td>
<td>Likelihood</td>
</tr>
<tr>
<td>R4</td>
<td>0.7</td>
<td>$4.5 M</td>
<td>0.7</td>
</tr>
<tr>
<td>ROW cost</td>
<td>0.4, 0.6</td>
<td>6m, 12m</td>
<td>0.5</td>
</tr>
<tr>
<td>E2, E3, E4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental OK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>0.5</td>
<td>$0.5 M, 6 m</td>
<td>0.25</td>
</tr>
<tr>
<td>Permits</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input to the Risk Management Process requires the same care and balance of perspective (bias) that is required for basic risk assessment.
Results & Deliverables

Process can be implemented at different stages of project. Effects of risk management and VE can be directly assessed.
Case Study - Summary of Pittsburgh North Shore Connector LRT Project

- **Scope:** Expansion of existing LRT system to support redevelopment and link to North Shore/Convention Center
- **Owner:** Port Authority of Allegheny County (PAAC)
- **Issue:** Funding proposed to FTA (project selected to be FTA demonstration of risk-based approach)
- **Status:** Assessment in June 2003 at 30% design stage
  - Assessment
  - Risk Management
- **Outcome:** Proposal for FFGA > “Recommended Status” (2004)
- **Status #2:** Updated assessment in June 2004 at 60% design stage
2003 Assessment Results

Total Project Cost (YOE $M)

Budget

$368 M

Project Opening Date
2003 Risk Management Targets

Key Cost Risk Management Targets

1. Additional Ground Control for TBM
2. Time to complete systems contracts
3. Uncertainty in vehicle costs
4. Relocation of existing utilities
5. Clarity of contract documents
6. Dispute resolution process
7. Funding strategies and need for FFGA and/or other funding source

Potential cost reduction - $9M
Project Changes from 2003 to 2004

- Risk Mitigation Plan implemented ( - $9 M)
- Change in Schedule (six month delay)
- Change in Financing Plan and assigned costs ( + $10 M)
- Change in Scope (some up some down, net increase)
- Design brought to 60%+ (some at 90%+)
- Reassessment in June 2004
2004 Assessment Results

Note budget increase $10 M

Total Project Cost (YOE $M)

Opening Date (later of Gateway and Convention Center)
Comparison of Unmitigated Costs

$378 M

June 2004 Update Unmitigated
July 2003 Unmitigated

Total New Starts Project Cost (YOE $M)
2004 Risk Mitigation Actions

Key Cost Risk Management Targets

1. Implement new PAAC Policy to constrain scope changes for all LRT Stations
2. Alternative design concepts for fire/safety sprinkler systems
3. Improve scheduling and design for temporary construction impacts on Wood Street Station
4. Revise design for ROW “take” on Miller Building
5. Repackage contracts for systems
6. Allow project contractors to do moves on private utilities
7. Mitigation Package A

Potential cost reduction - $ 15 M
### Example of Risk Mitigation Element

<table>
<thead>
<tr>
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<tr>
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</tbody>
</table>

Cost of building and demolition costs are uncertain. Base assumes full take, demolition, and business relocation. However, full vs. partial take issue is still not resolved (not accounted for in risk assessment; included under mitigation). Base includes $4.5M for property and $1M for demolition.

<table>
<thead>
<tr>
<th>Mitigation actions:</th>
<th>Replace with:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• There are three options: a) current plan is implemented; b) current plan plus risk, c) alternative for partial replacement. Option c) would involve reconstruction of building for owner (CSC) and would require partial demolition and removal of existing building and replacement with new addition on other side of building. Would reduce take to 1/3 of full, but adds cost to implement. Could be a net opportunity relative to the base (outcome “c” to right). Plan needs to be coordinated with (and sold to) owner.</td>
<td>Replace with:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. 0 (base is valid)</td>
<td>a. 5%</td>
</tr>
<tr>
<td></td>
<td>b. 1.0 (original risk)</td>
<td>b. 50%</td>
</tr>
<tr>
<td></td>
<td>c. -2.0 (net savings relative to base)</td>
<td>c. 45%</td>
</tr>
</tbody>
</table>

**Note 1.** Not necessarily on critical path; can be identified with additional effort.
Mitigation Package A

- Implement Design Review Board
- New design manual and new “terms and conditions”
- Effective implementation of OCIP
- Different contract packaging (i.e. combine systems contracts)
- Better define limits of work for interacting contracts
- Constructability reviews
- Advance schedule for design reviews/architecture reviews
- Additional PAAC and CM resources to expedite decisions
- Improved contractor interfaces/partnering/incentives

Major contribution from SME’s in developing this plan
Summary

• 2003 Project Assessment and Risk Management Plan provided targets for $9 M of cost reductions
• These targeted Risk Management actions were successful but other project changes required more action
  - Change in Schedule (six month delay)
  - Change in Financing Plan and assigned costs
  - Changes in Scope
• 2004 Reassessment and new Risk Management Plan identified an additional $15 M of potential cost reductions
• Project development is dynamic - risk-based project assessment is dynamic. Project updates bring value.