“Cost Estimating and Risk - Management for Tunneling and Infrastructure Projects”

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Sydney Harbor Bridge +200% *
Sydney Opera House +1,400% *

ITA World Tunneling Conference, Istanbul
May 11th, 2005

* cost over-run over “budget”
### Examples of Project Cost Growth, US(*)


<table>
<thead>
<tr>
<th>Project Description</th>
<th>Percent Over Budget</th>
<th>Orig. Est. (in $mil.)</th>
<th>Current Est. or Actual (in $mil.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastside Reservoir Project</td>
<td>11%</td>
<td>1311</td>
<td>1311</td>
</tr>
<tr>
<td>L.A. Metro Red Line (Segments 1, 2)</td>
<td>12%</td>
<td>1970</td>
<td>2190</td>
</tr>
<tr>
<td>L.A. Central Pub. Library Renovation</td>
<td>14%</td>
<td>4007</td>
<td>4502</td>
</tr>
<tr>
<td>S.F. BART Extension to S.F. Int Airport</td>
<td>25%</td>
<td>109</td>
<td>125</td>
</tr>
<tr>
<td>No. Outfall Sewer (San Fernando Valley)</td>
<td>30%</td>
<td>1200</td>
<td>1500</td>
</tr>
<tr>
<td>Central Artery / Tunnel (Boston)</td>
<td>40%</td>
<td>8000</td>
<td>11200</td>
</tr>
<tr>
<td>Staples Center Arena (Los Angeles)</td>
<td>50%</td>
<td>250</td>
<td>375</td>
</tr>
<tr>
<td>Sound Transit 22 mi. Light Rail Seattle</td>
<td>50%</td>
<td>2400</td>
<td>3600</td>
</tr>
<tr>
<td>L.A. Convention Center Addition</td>
<td>61%</td>
<td>310</td>
<td>500</td>
</tr>
<tr>
<td>Channel Tunnel</td>
<td>67%</td>
<td>9210</td>
<td>15350</td>
</tr>
<tr>
<td>Coor’s Field (Denver)</td>
<td>75%</td>
<td>123</td>
<td>215</td>
</tr>
<tr>
<td>Chek LapKok Airport Rail Link (HK)</td>
<td>76%</td>
<td>1560</td>
<td>2750</td>
</tr>
<tr>
<td>Los Angeles City Hall Retrofit</td>
<td>81%</td>
<td>362</td>
<td>656</td>
</tr>
<tr>
<td>Reagan Bldg. &amp; Trade Ctr. (Wash, D.C.)</td>
<td></td>
<td>153</td>
<td>300</td>
</tr>
<tr>
<td>Los Angeles Metro Red Line (Segment 3 No. Hollywood)</td>
<td></td>
<td>110</td>
<td>274</td>
</tr>
<tr>
<td>L.A. Coliseum Repair</td>
<td></td>
<td>35</td>
<td>93</td>
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<tr>
<td>Disney Concert Hall</td>
<td></td>
<td>35</td>
<td>100</td>
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<tr>
<td>Getty Cultural Center, LA</td>
<td></td>
<td>165</td>
<td>166</td>
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<tr>
<td>El Toro “Y” Freeway Modifications</td>
<td></td>
<td>233</td>
<td>163</td>
</tr>
<tr>
<td>Denver International Airport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.A. Metro Red Line (Segment 3 No. Hollywood)</td>
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<td></td>
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</tr>
<tr>
<td>Los Angeles Downtown Cathedral</td>
<td></td>
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</tbody>
</table>

(*) Similar examples exist world-wide

Prepared 2-26-01 by LACMTA Construction Div. Program Mgmt.
The Flyvbjerg Study (June 2002)

- Cost estimates* have been “系统ically misleading”
- A wide range of projects have this problem
- This condition has existed for a very long time (70 years)
- This cannot be explained by normal errors / random results
- Best explained by “strategic misrepresentation”
- What’s the real story?

* Cost estimate at time of decision

Note - Flyvbjerg’s paper was published after WSDOT developed CEVP®
Early optimism regarding cost estimates

- We are optimistic in understanding and managing scope
  - A PMI study found that the real scope, cost, schedule - for a wide range of project types – was generally about TWICE the initially envisioned scope/cost/schedule

- Results:
  - Low estimate in the beginning – leads to problems:
    - Cost and schedule over-runs, claims and disputes
    - Lack of funding for other projects
    - Media investigation negative publicity
    - Many more impacts
  - Findings (Reilly & Thompson, 2000)
There are significant cost and schedule overruns suggestive of poor management in at least 30%, and probably more than 50%, of the projects.

As reported by the Owners, factors that most commonly influence the success or failure of the projects were:

- Expertise, capability and policies of Owners
- Local political structures & historical circumstances
- Local procurement procedures / requirements
- Management structures / “stakeholder” management
- Lack of provision for, and control of, external events
In the beginning there may be a large potential range for a project’s ultimate cost or completion.

How to estimate the potential range of cost and schedule?

We can manage uncertainty (both risks and opportunities) - using logical & reasonable risk identification, quantification and mitigation processes - in order to better manage to deliver the project at the lowest possible cost....
Cost may turn out to be over twice the initial projections (with new project scope, delays and time cost of money)

Complex project, difficult management task, long time period involved, many political changes

Secondary but very significant “mitigation” requirements = new scope

Many success stories

See Fred Salvucci’s article (ITA Amsterdam 2003)
The 1987 Facilities Plan for the Boston Harbor Cleanup Project presented a range of costs from $4 to $4.9 billion.

In 1992, in the very early stages of construction, a thorough review of the project cost was performed and the estimate was fine-tuned to $3.65 billion. When the project was completed a decade later, the final cost was $3.8 billion.

The media drew from the early planning another number, $6.1 billion, that included additional project elements and a very generous inflation factor.

This number projected large rate increases that created public credibility problems - this drove the cost refinements made in 1992.
WSDOT’s(*) concern - poor cost estimates threaten public confidence. Observations:

- The traditional approaches to early estimating match poorly with the public’s intuitive understanding of
  “what engineers can tell us......”
- The meaning of “contingency” in an estimate mystifies ordinary citizens.
- “Development” of an estimate is seen by the public as evidence of doubtful engineering competence or, worse, intentional masking of unanticipated cost growth

(*) Doug MacDonald who was responsible for the Boston Harbor Project’s disciplined approach came to the Washington State Department of Transportation (WSDOT) in 2001
Goal: “WSDOT must build, and maintain, public trust and confidence”

- **Problem**: Cost Estimating is complex and inexact, but:
  - Current budgeting procedures require that large projects provide “precise” cost numbers to facilitate budget and decision making processes - sometimes at a very early stage.
  - Unfortunately, large projects can, and do, experience large cost changes - usually increases. These changes are not well understood by the public and lead to an erosion of public confidence in the agency.

- **Solution**: WSDOT decided to develop a more reliable cost estimating procedure and to open the “black box” of estimating - so the public can be better informed and elected officials can make better decisions (“there is no black box”)
Principle: Avoid single number estimates

- The final cost is subject to many variables
- These variables significantly influence the range of “probable projected cost”
- A single cost number represents only one possible result - depending on the many variables, assumptions and conditions
- The variables are not all directly controllable or absolutely quantifiable
- Therefore, cost estimating must consider uncertainty using a logical, structured process
Key risk and management factors involved

**Basic Technical**
- Technical
- Geological
- Environmental
- Funding & budgets
- Organization/Strategy
- Contractual Approach
- People - Capability
- Available Resources

**But, just as important:**
- Media & publicity
- Political Changes, Public Requirements
- Historical factors
- Risk & uncertainty must be included
WSDOT’s CEVP® Process, January 2002
“A sophisticated management, engineering & communication process” (Client’s statement)

- A compressed peer-level (“due diligence”) type review of scope, schedule and cost of WSDOT Projects using internal project staff and external subject matter experts
- An assessment of the quality, completeness and assumptions of the Project estimate
- Include uncertainty (potential risk and opportunity) to address the potential ranges of cost and schedule
- From the explicit risks identified, develop and implement a Risk Management Plan - reduce risk costs
- Communicate to Decision Makers, Media and Public

(CEVP® stands for Cost Estimate Validation Process)
Risk models have existed for some time (Einstein DAT 1974; Grasso; Roberds.....)

**RMP: Risk quantification - The system DAT**

**Scatter plots of a project duration and cost**

Comparison of project solutions with different site investigation extents: partial [A] and complete [B]

- Example: cumulative probability for completing the project within 7 years
  - Solution A: 82%
  - Solution B: 99%

**Duration [years]**

- Frequency [%]
- Cumulative frequency [%]

**Relative cost**

- Frequency [%]
- Cumulative frequency [%]

**Duration [years]**

- Frequency [%]
- Cumulative frequency [%]
**CEVP® Participants / Process Steps**

**Workshops:**
- Preparatory data
- Base cost & risk identification
- Risk management, risk management plan

**Participants:**
- Project team
- CEVP review team
  - facilitator / elicitor
  - base cost assessments
  - risk assessments
  - technical experts (validate)
  - modeler

1. Review Project Scope and Strategy (Flow Chart and Assumptions)
2. Review Activity
   - Base Costs, Durations, and Escalation Rates
3. Develop Cost and Schedule Uncertainty Model
4. Develop Risk Registry
5. Assess Risk Inputs
6. Evaluate Uncertainty and Sensitivity in Cost and Schedule
7. Identify and Evaluate Risk-Management Strategies and Other Plan Changes (optional)
8. Report Results
9. Update (optional)
CEVP® - Base Cost Determination

- Determine the “base” costs - the most probable cost that can be expected if the project goes exactly as planned.
- Remove all contingency - i.e. provision for unknowns (representing uncertainty = risk + opportunity).
- Consider at the particular stage of the project:
  - What are our assumptions? Where do they come from?
  - How valid are they, how do we know?
  - What do we know we know? (components, units, prices)
  - What do we know but can’t quantify? (allowances)
  - What do we know we don’t know? (normal uncertainty)
  - What don’t we know that we don’t know? (gross uncertainty)
Risk workshop - Risk Process

- Identify/list current concerns
  (Examine key issues, causal drivers, relationships)
- Compile list of credible/possible events
  (consequences & and opportunities)
- Estimate the probability of each event
- Estimate the consequence (impact) of each event
- Review the product of consequence (impact) and probability = RISK
- Rank risks - prioritize for attention
- Determine mitigation measures for top ranked risks
- Determine cost/benefit of mitigation measures
- Determine risk management plan for all risks
- Maintain risk management plan, update regularly, keep awareness of other risks (residuals)
EXAMPLE OF RISK IDENTIFICATION AND MITIGATION DETAIL

Risk item: T-10 Commercial Property Value

Issue: Project ROW costs were developed by applying a percentage increase to the assessed valuations for each parcel. During review the estimated cost of commercial properties carried in the ROW estimate for the project have been updated, and the multiplier increased to 75% of the assessed value, to better reflect current market conditions. There is a low level of confidence in the updated values and it is estimated that actual market conditions may be as high as 100% of the assessed valuations.

Impacts: There is an 85% probability that actual market conditions will increase the cost of acquiring commercial properties by $25M.

Likelihood: 85%.

Mitigation: Monitor the commercial real estate market and track the actual cost of recent transactions. Keep the project ROW estimate up to date and reflective of the current commercial property real estate market. Buy early if appropriate.
CEVP® - Results

- Combine base costs and uncertainty (risk and opportunity) to create the range of potential cost & schedule

Bar chart showing the probability distribution of total project cost (YOE $M).
Risk Reduction & Management Plan

- Risk mitigation actions can be taken, based on the explicit risk events that are causing the higher-range costs.
What does it take to do CEVP®?

- A knowledgeable/committed owner (who wants to know the potential cost)
- A well-shaped project estimate
- Available/involved project team members
- Sufficiently independent subject matter experts
- Skilled risk and cost elicitators (debiasing)
- Risk modeling - technology and experience
- Time / available funding
The WSDOT Results

- WSDOT CEVP’d ten projects
- Total cost was $3 million (approx 0.01% of project costs)
- Hallmark was collaboration of WSDOT’s project teams and the CEVP® consulting team
- Formal evaluation reports prepared - presentations made to project staff and WSDOT leadership
- Cost Risk Assessment (CRA) being implemented extensively at WSDOT, including process for small projects
- WA legislature funded a $5m study to evaluate the results of the CEVP® process - the current results are positive
SUMMARY INFORMATION PACKAGE
June 2002

WSDOT MEGA-PROJECTS
COST ESTIMATE VALIDATION PROCESS

SUMMARY
INFORMATION

WSDOT - Northwest Washington Division
Urban Corridors Office

This package corresponds to the project information released to the Public, Local Decision Makers and the Press June 3rd, 2002
The Public-release effort produced interesting results

“Giving citizens a range of costs, including full disclosure of the variables, “is not only politically smart, but it’s common sense”…”

John Reilly, reported in the Seattle Post-Intelligencer, June 9 2002

“Shocking or not, the Department of Transportation Has performed an unprecedented public service with these latest cost estimates. It is a much-needed dose of fiscal reality. The department offered realistic cost-range estimates”
WSDOT’s current focus: Development of the Process

- Continue to use CEVP consistently
- Scale the process for efficient use with more typical projects & use a simpler shorter process for smaller projects (Cost Risk Assessment)
- WSDOT is building internal expertise
  - Subject Matter Experts
  - Modelers
  - Cost and Risk “Leads”
  - Project Teams
  - Regions/Management

- The U.S. Federal Transit Administration (FTA) has aggressively moved to include cost-risk assessments and risk mitigation for all major capital projects. They now require risk management, linked to the cost-risk process - see FTA’s “Risk Assessment Methodologies & Procedures”.

- The U.S. Federal Highway Administration (FHWA) is sponsoring CEVP training by WSDOT + CEVP Consultants - the first workshop was held May 19 & 20, 2004 in Seattle.

- Several U.S. State Departments of Transportation are running demonstrations of CEVP to evaluate its use.
Thank You for your attention.

Further Questions - email John Reilly:
John@JohnReillyAssociates.com
or go to: www.JohnReillyAssociates.com
(paper & presentation .pdf available on the website late May)