“A Short History of Risk Management”

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John Reilly, P.E., C.P.Eng.
Recent Papers & Presentations

ALTERNATIVE PROCUREMENT & CONTRACTING FOR MEGAPROJECTS

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John Reilly Associates International

UCA, Fox Conference New York
January 22nd 2013

Megaprojects – Successes, Lessons Learned

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Construction – You Need Risk-Based Cost Estimating
Contracting Practices Session, June 8, 2015

Risk Management – Correlation and Dependencies for Planning, Design and Construction

Philip Sander
Alfred Moergeli
John Reilly
Presentation will cover

1. Risk, Risk Management (RM) through history
2. Examples of problems - cost blow-outs
3. Risk initiatives last 25 years + UCA/AUA work
4. Risk Codes and Guidelines
5. WSDOT’s CEVP® - Precursor to Advanced RM
6. Risk Development, Advanced Risk Processes
   - Risk identification, mitigation and management
   - CEVP® DAT, RIAAT
   - Adoption by US Agencies - FHWA (eBook)
   - Risk in Construction, Correlated & Dependent risks
   - Integrated Models – risk based cost & schedule
7. RM Examples – Lake Mead tunnel, New Lima Airport
8. Conclusions / Questions
Murphy’s law – “If anything can go wrong it will…”

1st corollary to Murphy’s law
“Murphy was an optimist…….”

“If everything seems to be going well, you have obviously overlooked something.”

1st inversion of Murphy’s law -
“If things could go right they might….”

(that’s what we’re here to discuss today…..)
“A plan, whatever it may be, must be made for the bad ground, it must be calculated to meet all exigencies, all disasters and to overcome them …”

*Statement by Marc Brunel after the water-break-in of 1831 at the Thames River Tunnel*

Heathrow Tunnel collapse, 1994

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**Heathrow failures highlight NATM (abuse?) misunderstandings**

Shani Wallis
Some historians believe the concept of risk arose through gaming. People in ancient civilizations played games with dice and bones – games that evolved into chess and checkers over 2000 years ago. It is possible to trace the use of insurance back to ancient times. Mutual aid and burial societies have been documented from the earliest days of ancient Rome. These are considered the precursors of modern insurance companies. Some historical evidence that gaming gave rise to probability theory comes from writings by Dante and Galileo (many others). The mathematicians, Pascal and Fermat, wrote each other about games of chance in the 1600s - a correspondence that is believed to have given rise to modern probability theory.

See: "Against the Gods: The Remarkable Story of Risk," Peter L. Bernstein
The *Code of Hammurabi* is a well-preserved Babylonian code of ancient Mesopotamia dating back to about 1754 BC. It is one of the oldest deciphered writings of significant length. Nearly 300 precepts – of interest to us:

- 229: If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.
- 230: If it kill the son of the owner the son of that builder shall be put to death.
- 232: If it ruin goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.

Under this system, you should be using risk management……

For specifics of the Code see: [http://avalon.law.yale.edu/ancient/hamframe.asp](http://avalon.law.yale.edu/ancient/hamframe.asp)
Suleyman Mosque in Istanbul was built for Suleyman the Magnificent by Mimar in 1557.

On a tour, I was told that the required Mimar to finish the Mosque in 6 years or be put to death.

However, the site was unstable and needed to be preloaded for several years which Mimar did.

He was able to finish the mosque within the 6 years and was richly rewarded by Suleyman.

So, a basic theme for several thousand years was to identify a need or result and mandate a severe penalty if not achieved or reward if successful.

What’s different today?
Recent Timeline, Risk Management

- UK, Australia, NZ address risk as part of Alliancing with owner-engineer-contractor pain-gain provisions
- 1999 Discussions – AUA (UCA), ITA, BTS + International Conferences
- 2001 AUA Conference on cost, Seattle
- 2002 WSDOT develops the CEVP risk-based cost validation process – leads to explicit risk definition and adoption of RM as a practice
- 2003 briefing to FTA & FHWA - adopt as a policy (now practice)
- RM process recognized and implemented by States and Agencies – understanding grows as applications become routine and more professionals are engaged, conference topics routinely include risk
- Better processes - integrated risk + schedule models (RIAAT)
Continuing Risk Improvements
- Guidelines, Manuals, Procedures, etc.

New risk characterization, definition....
Risk correlation, dependencies, multiple occurring...
Cost and Schedule Problems Drive RM

- Many large, complex transportation projects have exceeded their budgets and schedules
- Work from 1999 in the US (AUA/UCA) & Internationally (inc. ITA)

London Jubilee Line  +67%
Golden Gate Bridge cost $35 million, completed ahead of schedule and under budget by $1.3 million.

Channel Tunnel +80%

Boston Central Artery / Tunnel  +80-100%

Percent is added cost over first announced budget.
Many other examples.
Examples of Project Cost Growth, US(*)

(*) Similar examples exist world-wide

Prepared 2-26-01 by LACMTA Construction Div. Program Mgmt.
Out-turn Cost - Scope and Optimism

- Planning & Scoping – we are optimistic.
  - A PMI study found that the real scope, cost, and/or schedule - for a mix of projects - was about TWICE the initial scope/cost/schedule

- Results:
  - Low estimate in the beginning – leads to problems
    - Cost and schedule over-runs
    - Resource competition – deprives other projects
    - Media – investigation, negative publicity

NASA, Apollo 11 (James Webb)
Apollo program $24.5b as reported to Congress 1973.
Final $109b w escalation + added scope.
WSDOT was planning several mega-projects, possible total value over $20 billion – they were concerned regarding the out-turn cost.

The Secretary of Transportation asked us to develop a better cost estimating process. We added explicit risk management.

We called it CEVP® (Cost Estimate Validation Process).

Questions that we asked:
1. Can we improve the cost estimating process?
2. Who can be objective (unbiased) about an estimate?
3. How can we include risk and “validate” costs?

Key Conclusions:
1. We need to examine cost estimates and assumptions, using independent experts to “validate” the base cost estimate.
2. We need to include risk (i.e. uncertainty) using statistical risk and decision analysis methods.
Key Policy – “range of probable cost”

- In the beginning there is a large potential range for a project’s ultimate cost - depending on events that may occur.

Future costs must be represented by a probability distribution - a range of costs.

- A single cost number represents only one possible outcome, depending on circumstances and risk events that affect cost.

- These circumstances and risk events are not directly controllable or absolutely quantifiable.

- The risk events, if they occur, produce consequences which add cost/time to the project (sometimes opportunities).

- Therefore, cost estimation must include risk (i.e. account for uncertainty) using a logical, structured process.
- Project team and CEVP team, including Subject Matter Experts, are brought together in workshops.
- Independently validate base costs.
- Promote open discussion to define risks – probability and impact – and identify issues of concern.
- Create a mutual understanding of key issues, project characteristics, actions which need to be taken.
- Model base costs + risk costs (and schedules) to produce an estimated range of probable cost and schedule.
- Compare range of probable cost and schedule to authorized (or planned) budget and schedule.
- Identify risks that need to be managed, leading to risk management plans.
- Create clear implementation structure including cost components (base cost, risk, escalation), risk mitigation and change order management.
Risk mitigation + cost-containment actions can be taken, addressing risks driving high costs – to reduce the “range of probable cost”

Allows structured risk and cost management to approved budgets

Risk Management:
Work to reduce the probability and/or consequence of these high-impact events

Seattle Monorail
CEVP+ Application to WSDOT Megaprojects

CEVP+ Process:
CEVP+ Value Engineering + Risk Mitigation + Scope Changes (2+ Cycles)
Specific CEVP+ Results (2010)

60% mitigated probable cost
$1.96 billion
“No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored”.

Sir Michael Latham 1994

**Impact**: The effect on the project or its objectives, measured in terms of safety, cost, schedule delay, quality of construction or other requirement (+ or -).

**Probability**: Chance of a risk event occurring

**Risk**: Combination of impact and probability

**Residual risk**: Risk remaining after initial risks are addressed

**ALARP Principle**
“As low as reasonably practicable”
There needs to be a defined risk acceptance criteria. These criteria include:

- A limit or threshold above which the risk is considered **unacceptable** and **must be reduced**.
- A limit below which consideration of further risk **reduction is not required**.
- An area between these two limits where risk response is considered and may be **implemented according to circumstances**, e.g. using the “as low as reasonably practical” principle, considering benefit vs. cost analyses.
Risk Management uses a defined Risk Policy and Process (e.g. Lima Airport)

Legend

- Direct communication & action
- Indirect communication, information, coordination

Mila Sotelo, Risk Manager

Risk Management - Process

Cycle for updating risk registers & action plans, after risk workshops and risk information meetings with related organizations
Where do risks come from?

- Stable and known processes - “If this, then that”
- Chaotic systems - variable within bounds – “If this, maybe that, but not that”
- Chain-of-events, linkage and inter-relationships - “Because of this, associated with that, then that”
- Events caused by intent - directed threats

Specific types of risks may need to be considered e.g.

- Political cost + schedule pressures lead to conditions that favor a particular type of TBM
- Agency decisions re design responsibility, plus the form of contract, create major changes and claims leading to high costs
- Ground type + high water pressure conditions require long closed mode operation at high pressure leading to full face repair

(*) From a condition or decision that leads to multiple, related risk events
Details in other presentations (see websites)

Risk Management – Correlation and Dependencies for Planning, Design and Construction

Philip Sander
Alfred Moergeli
John Reilly
Correlation

Evaluating the financial impact of a risk in two items...

Estimated delay time:

- 5d
- 10d
- 20d

Time-related costs: $30,000 per day

Labor costs: $15,000 per day

Independent result (not realistic)

Perfect correlated

Always the same delay time for both items
Specific Distributions for each Risk

Poisson most likely: 2.00

Distribution Function (Impact in TUSD)

- Scenario one cave-in
- Scenario two cave-ins
- Scenario three cave-ins
- Scenarios four and more cave-ins

Probability that no cave-in will occur

Deterministic Approach: $2 \times 65,000 = 130,000$

Ref: Sander & Moergeli
Analysis of Complex Events

- **Fault tree analysis**
  Fault tree analysis can be used to analyse a single or combined causal connection (relation) that precedes a negative event. Fault tree analysis is utilized either with or without quantifying probabilities for events. By using this tool, complex problems with many interacting events can be structured.

- **Event tree analysis**
  The description of the development from an initial event, through possible sequences to a defined final state can be carried out by event tree analysis. Assessing probabilities for different outcomes give a quantitative analysis.

- See also Decision tree analysis.

Excerpted from ITA 2004 Guidelines for tunnelling risk management: International Tunnelling Association, Working Group No. 2
Søren Degn Eskesen, Per Tengborg, Jørgen Kampmann, Trine Holst Veicherts
One risk may trigger another... Example: Event Tree Analysis

- **TBM advancing through fault zone**: 87.5%
  - **TBM buried**: 80%
    - **TBM deadlocked**: 50%
      - **TBM bypass tunnel**: 50%
    - **No further event**: 20%
  - **No event**: 12.5%
Event Tree + Fault Tree Analysis

- Necessary for an integrated analysis of complex events
- For very low probability events (probability $10^{-6}$ or less)
- There are rare, but potentially very high impact events that can occur.
- Their impact is very much out of proportion to their probability.
- Because they have very low probability they sometimes are not sufficiently considered in risk mitigation.
- It is important that better consideration be given to such events – this is difficult to do.
- Additionally, the possibility of “black swan” risk events is real.
Suggested Risk Response Process

- From the results of risk characterization rank risks according to severity and consequences (Tornado or range impact diagrams)
- Review the probability of these risks and classify:
  - High consequence/high probability events rate most highly
  - Followed by medium consequence/medium probability events
  - Followed by high consequence / low probability events – these are “special” cases
- Recommend risks to be considered for action
- Develop risk response options for the recommended risks, considering risk acceptance criteria.
- For these options determine a benefit/cost ratio.
- Confirm the action in the risk register.
- Approve actions by authorizing the recommended action by the “risk owner”
- Implement the risk response action.
- Monitor and manage the risk response plan, update as necessary.
Risk Management, by Project Phases

- We have good processes and tools for identification and definition (characterization) of risk in the planning and design phases.
- Specifications require contractor to manage construction risks – and in some cases to share with the Owner(*).
- This is not universally accepted but we look to a more aligned owner-contractor relationship.
- We need to advance the contractor’s explicit risk management capability, including understanding, quantifying and sharing risks.

(*): See ITA Guidelines
Risk Partnership – Lake Mead Tunnel

- Awarded March 2008 $447 million
- Compliance with ITIG Risk procedures
- Starter tunnel problems 2010-2011 - delay, cost
- Agency & Contractor working “in partnership”
- TBM drive and mate to intake chamber successful (330’)

Intake fabrication, lowering in lake (over 330’ deep), Tremie concrete 12,000 cy, 11 days, TBM in chamber.
Compliance with the ITIG Code

Contractor and Owner (SNWA) were proactive to “work in partnership” and used advanced risk management

Engaged risk facilitator to define risk process, risk workshop structure, risk compliance reports

Advanced risk workshops for sensitive operations – e.g. final drive of TBM into sunken intake structure 330’ deep in lake – focus on inter-dependent risks and correlation of potential events.

Successful contract from Owner and Contractor’s points of view.

- New Airport Terminal + 2\textsuperscript{nd} Runway, fast-track, EPC Contract, non-Governmental Owner, full implementation of advanced Risk Management.

- Initial 4-day risk workshop – Program staff + executive management

- Define best practices for Owner (LAP) re Risk:
  - Risk Policy
  - Risk Management Plan
  - CEVP – validate costs, define risks, model cost & schedule using:
    - RIAAT advanced modeling – integrated cost & schedule
    - PRAT Risk Register tool for workshops & input to RIAAT
Team Alignment to focus the Program Delivery Team on key objectives and create an efficient organization.

Partnering with the EPC Contractor to work in partnership to add value, reduce risk and meet cost, schedule, quality and operational goals.

“Creation of relationships that promote the achievement of mutual business and functional objectives”
SUMMARY

- Risk Management has advanced substantially in the US and Internationally – both process & application
- RM process is well understood, guidelines are available
- Advanced RM processes and models are available
- Industry is applying RM principles more extensively
- Federal Agencies and States are involved and active
- RM educational initiatives have/are being developed (FHWA/NHI)
- Better management processes include risk (e.g. Lake Mead, Lima)
- Need construction contractors to advance risk management, improve processes and work more directly with owners – particularly for:
  - Interface and “shared risks”
  - Align risk processes to the benefit of owner and contractor.
- RM should use “best practices” from other countries (e.g. UK, Australia, NZ, Canada, Europe, Peru)
RECENT REFERENCES

See also Reilly & Sander websites


www.JohnReilly.us

- Key topics information can be accessed from the tabs on the left side.
- You can download presentations and the papers on risk from the links in the boxes.