Project Controls EXPO
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The Problem of Forecasting Realistic Time and Cost Contingencies For Megaprojects

Presented by

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About the Speaker

Colin H Cropley BE(Chem), PMP, Certified PRINCE 2 Practitioner
Managing Director of Risk Integration Management Pty Ltd

- Over forty years' experience of project management, project controls and risk management
- Experience in project and risk management consulting, software development, training and lecturing, in sectors including Infrastructure, Oil & Gas, Minerals Processing, IT, Power and Defence
- Has conducted risk management processes, schedule and cost risk analyses and training for companies including BHP Billiton, BP Australia, Downer EDI, Leighton Contractors, Oman LNG, Origin Energy, Santos, Tenix Defence, Thiess and Woodside Petroleum
- Guest lectured in project & Risk management at universities since 1991 and delivered papers at many project management and controls-related conferences, including AACE International's Annual Meetings, the ICEC's World Congress, PMI's PMOz & PMICoS
- Member AACE International, Australian Cost Engineering Society (ACES, on National Committee) & Risk Engineering Society, both Technical Societies of Engineers Australia
- Was Chairman of Victorian Primavera Users Group 1997 to 2009

Presentation Outline

- Megaprojects hard to deliver to budget and schedule – examples across sectors
- What makes megaprojects harder to deliver and forecast?
- Brief history of attempts to forecast project outcomes accurately
- Pros & Cons of CPM-based Monte Carlo Simulation methods
- A new approach based on old method in 2016 book by John K Hollmann: “Project Risk Quantification” – Systemic Risk
  - What Systemic Risk represents and how it is quantified
  - Relationship of Systemic Risk to risk quantified by usual methods
  - Quantifying Project Risk using Hollmann approach: Parametric + Expected Value (P+EV)
  - Pros & Cons of P+EV method
- Another way: combining P+IRA (CPM-based MCS methodology)

Oil & Gas Megaprojects that overran

- Greenfield LNG projects in Australia have all overrun time & budget since Darwin LNG (2006)
- >USD200 billion (A$280 bn) has been spent on LNG facilities in Australia in the last decade
- The ave Gorgon >45%$

QCLNG, GLNG & APLNG on Curtis Island near Gladstone, Queensland

Mining Project Overruns

- Australian mining megaprojects have a long track record of overrunning cost and time, but particularly in the resources boom between 2003 and 2013
- BHP Billiton had a number of notable overruns - their related Nickel Projects Ravensthorpe (WA, Nickel Concentrate) and Yabulu (QLD, Nickel Refinery) (2004-8) both overran forecast time and cost substantially through a serious of management and technical missteps
- [redacted] a Canadian Company, Yabulu to Clive [redacted]

Ravensthorpe Nickel Concentrator during construction

Yabulu Nickel Refinery

Infrastructure Overruns

- Various road and rail projects in Australia have overrun substantially in cost and time, such as Airport Link in Brisbane, WestConnex M5 in Sydney and Regional Fast Rail in Victoria.
- The Victorian Desalination Plant project was originally estimated at $2.9bn, but after several upwards announcements, it was revised to $4bn when awarded.
- The plant was built on a flood plain next to a wind farm and was delayed by flooding and wind, as well as industrial disputes.
- It ran 12 months late and hundreds of millions over budget, incurring Liquidated Dam
- As it was a PPP, subsequently sued each other

An aerial view of the Victorian Desalination Plant

Defence (& IT) Project Overruns

- It is a rare defence project that does not overrun its budget and timeline. Two megaproject examples are:
- Australian Air Warfare Destroyer Program. 3 ships ordered in 2007 for $7.9bn, due to be handed to the Navy between 2014 and 2016. This became $10bn (27%), with handover an estimated 33 months late (28%).
- Joint Strike Fighter (JSF) is Australia's largest ever weapons purchase, but so far it is at least 4 years late and well over budget. Original estimates per plane were USD40m each. By 2016, this had blown out to USD90m per plan[illegible]asily worsen.

HMAS Hobart prior to launch – May 2015


Lockheed Martin Joint Strike Fighter

- A notable fact about defence projects is that IT is often a major driver of time and cost overruns, due to complexity and technical debt (errors in code yet to be corrected).
- Non-Defence IT projects also overrun. Look up the Queensland Health Payroll System, which went from $98m to >$1.2b! Also merging of Customs and Immigration IT systems…

Why are megaprojects harder to deliver & forecast?

- Sheer scale and complexity – very difficult to project manage and control
  - Often require strong global coordination – design, procurement, fabrication and construction in different countries
  - Use of modules to reduce expensive site labour increases project stressors, bringing forward previously late project scope such as Electrical & Instrumentation installation. Lateness creates carryover work
  - Speed kills – urgency of getting to market drives attempts to overlap phases and take shortcuts, especially before Financial Investment Decision (FID).
  - A problem for transport projects: public announcement of project cost & timing before estimating…
- Risks that are seemingly independent tend to occur in clusters and act in co
- What cou to apply. Project o aged badly, bu ct…

Pluto Project large LNG modules being unloaded at Burrup Peninsula Site from special “low loader vessel”

Brief history of forecasting project outcomes

- After World War II, there was a boom in process plant construction, accompanied by widespread instances of cost and time overruns
- Through the 1950s to the 2000s, efforts were made to improve methods to forecast project cost and schedule outcomes:
  - In 1965, John Hackney (Cost Engineering pioneer and one of founders of AACE) produced the first practical, empirically based model for quantifying project risk. He elaborated this work in the 1970s.
  - In the late 1970s and again in the 1980s, Rand Corporation was commissioned by US DoE to study projects by 34 oil & chemical companies and develop better forecasting methods.
  - In 1987 author of Rand study, Ed Merrow bought the rights to the Rand Corp database, founded Independent Project Analysis, Inc and built a project benchmarking business that still flourishes.
  - From the 1990s onwards, AACE began publishing Recommended Practices on quantifying project time and cost contingencies, including parametric method based on Rand Corp work.
- In 1987, @Risk and Crystal Ball were released for PCs, making Monte Carlo Simulation (MCS) widely accessible and transforming project risk quantification.
  - The principle of ranging uncertain cost line items to produce probabilistic forecasts was appealing and more so when, in the 1990s and 2000s, MCS tools to range schedule durations appeared.

CPM-based MCS for Contingency Assessment

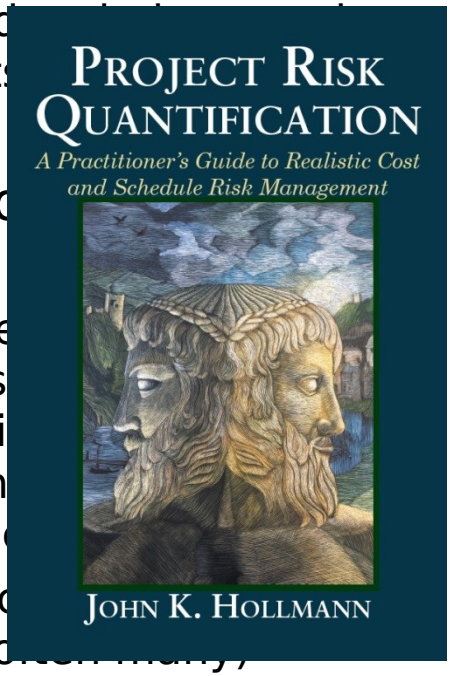
- Critical Path Method (CPM) based methods for assessing cost and schedule contingencies usually involve three elements:
  - Schedule Risk Analysis (SRA) of the project schedule or a summary of it, replacing task durations with probability distributions ("ranging") and running a Monte Carlo Simulation (MCS) to produce a probabilistic duration distribution for the project duration
  - Cost Risk Analysis (CRA) of the project estimate, replacing line item costs with ranging and running a Monte Carlo Simulation (MCS) to produce a probabilistic duration distribution for the project cost
  - Mapping of risk events with significant duration and cost impacts from the project risk register, also called "Contingent Risks" (<100% probability), into the above analyses of what is also called "Inherent risk" (100% probable, uncertain impacts).
- Our methodology, Integrated cost & schedule Risk Analysis (IRA), integrates these:
  - One analysis, overlaying cost estimate and risk events on schedule, splitting costs into Time Dependent (spanning relevant tasks) & Time Independent, ranging both kinds of costs & risk impacts
- Advantages of integrating cost and schedule risk analysis:
  - Unifying the drivers of project cost so all can be ranked and optimised in most cost-effective way
  - Enables threats to project to be reduced as part of process

CPM-Based MCS Problems

- The method is entirely bottom-up:
  - Starting with project inputs of schedule, estimate and risk register
  - No explicit reference to past project performance – how well have similar projects by the same or similar organisations, been executed in the past?
- The history of large and complex projects, especially megaprojects, paints a dismal picture of failing to meet time and cost targets
  - Pluto/Don Voelte encounter 2009 - count-down calendar vs. SRA forecast >6 months delay
- CPM-based MCS is known to be particularly poor at forecasting cost overruns
  - IPA warns project owners about this
  - Example of Santos GLNG Management Reserve – how to produce a credible forecast, even at P90!
- Likely causes
  - Groupthink optimism by project SMEs providing inputs to model
  - Reluctance to assign pessimistic ranges to costs
  - Difficulty of identifying major threats to project goals and assigning big enough impact ranges, especially to treated risks
  - Reluctance to assign substantial cost treatments (mitigations)
  - Inability to recognise the biggest threat of all to the project – the project delivery organisation

Project Risk Quantification" by John Hollmann

- Published in 2016, PRQ is (as sub-titled) "A Practitioner's Guide to Realistic Cost and Schedule Risk Management". It is written in two halves for two groups:
  - First half for those interested in accurate forecasting of project time & cost outcomes. It explains why risk quantification is important in projects, why realistic forecasting requires both looking back at the results of past performance and looking forward by using the Phase Gate system to define the project, its timing and its cost progressively (thus Janus, the Roman God of the Gates on the cover).
  - The second half is for QRA practitioners, explaining tools and
    used to achieve accurate cost and time forecasts for project
    important and practical guide.



- PRQ redefines the classification of risk by the metho
  quantify it:
  - **Systemic Risk** is the risk inherent in projects which has bee
    in past projects after removing significant project specific ris
    that would otherwise bias the data. It is due to systems acti
    project, particularly the project delivery system, but includin
    economic and social systems that interact with capital proje
  - **Project Specific Risk** covers those risk events in the projec
    that deal with unique risks to the project and excludes the (
    risks about the project delivery system
- About John K Hollmann

Project Risk – a new (old) way to assess it

- **To forecast Systemic Risk** time and cost outcomes of projects, Hollmann recommends using Parametric equations (Multi-linear Regression), based on past project performance and driven by proven drivers of Systemic Risk:
  - Scope Definition (poor maint.)
  - Team Development
  - Project and process complexity
  - Project Organisation quality
  - Project Controls quality
  - Quality and age of Cost Growth Data
- **For Project Specific Risk**, Hollmann recommends using a technique known as Expected Value (of risk events). It sums the significant (red or amber time and cost impact) project-specific risk events in the Risk Register, ignoring systemic and lower order risk events (covered by the data in the Systemic Risk past projects database)
- Expected Value of a risk is the Probability X Mean Impact of the risk. For MCS assessment probability distributions replace the mean values
- The EV method takes the project specific risk events plus Systemic Risk as Risk #1 for each of duration and cost impact cases (using log-normal schedule & cost probability distributions) and runs a MCS to provide overall distributions for time and cost.
- **This is known as the Hybrid P+EV methodology for contingency assessment**

Pros and Cons of Hybrid P+EV Method

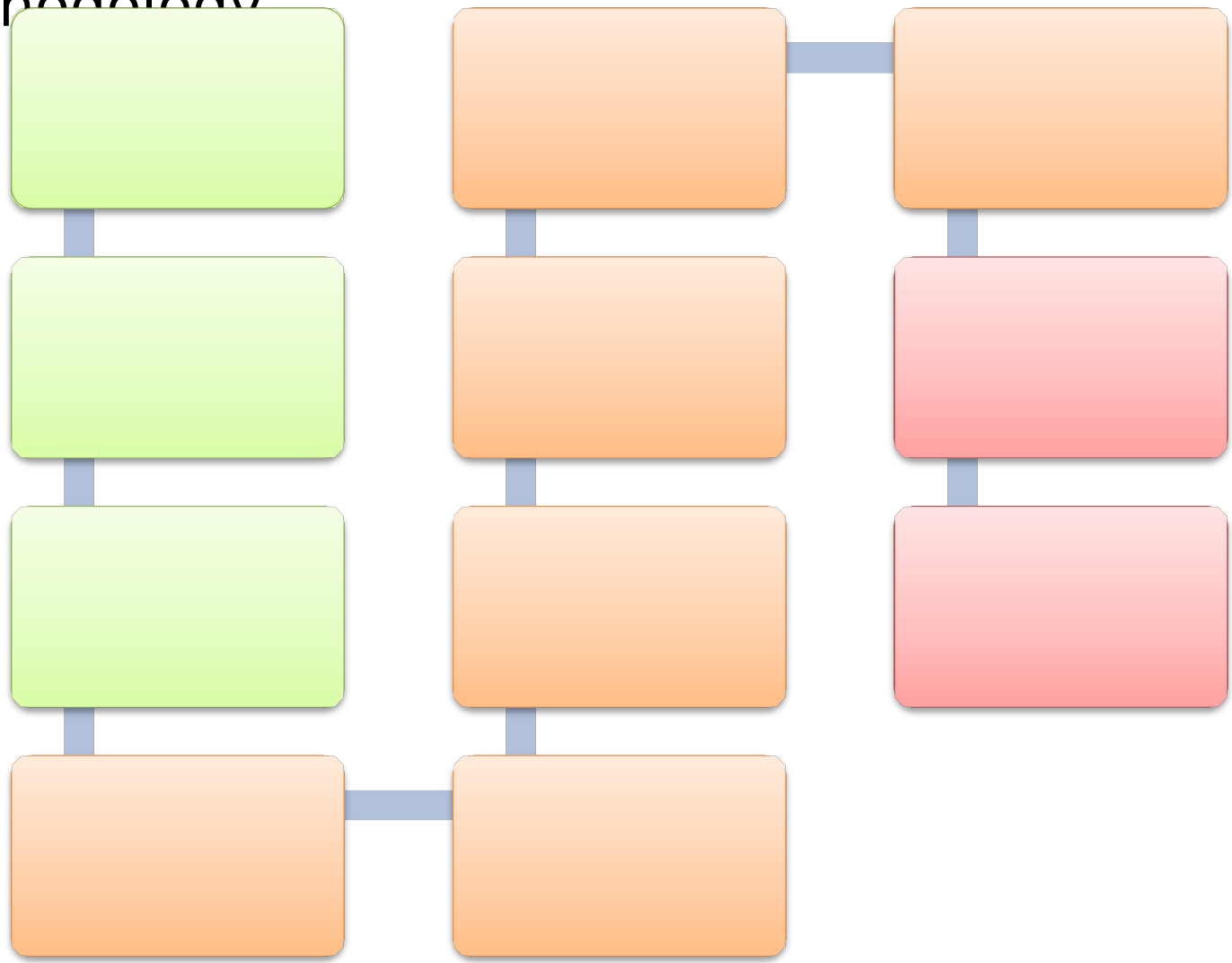
- Pros:
  - Unlike the CPM-based MCS methods for quantifying project risk and contingency, the P+EV method does not require a high level of expertise to be able to use it and is not difficult to use.
  - While it is highly desirable to be able to use the organisation's previous project performances to predict the outcome of future projects (which will itself bring substantial benefits in project management maturity and improved capital efficiency) it is not essential. Generic past project data forms the basis of Hollmann's Parametric Method.
  - As a top-down methodology, it involves obtaining qualitative answers to a series of questions about the key drivers of Systemic Risk, along with basic questions about the project execution time and cost, which configures the Parametric Equation's coefficients to forecast the project mean time and cost contingencies. The process may be completed in a couple of hours of workshops/interviews.
- Cons
  - Because it is a top-down assessment, it should involve senior management from the project delivery organisation, because the quality of the project organisation and team is the responsibility of senior management. Such people are not normally involved in QRA assessments.
  - P+EV does not optimise risk, it simply quantifies it.
  - The EV methodology require the conversion of project level schedule impacts into activity level schedule impacts and how those impacts may affect the project execution duration, without using a critical path method schedule for the

Overlapping of P+EV and IRA Methodologies

- It became apparent to us when comparing the P+EV methodology with the IRA methodology that they overlap:
  - The EV step is very similar to the mapping of risk events into the IRA plan to created the treated Risk Plan
  - But unlike the EV method, it does not require any assumptions – risk events can be placed exactly where they belong in the project schedule, even in multiple places
- The Venn Diagram at right shows the relationship between Systemic Risk and Inherent and Contingent Risk as modelled in IRA methodology
- To combine the Parametric and IRA methods requires two changes to IRA methodology:
  - Exclude Systemic Risks from the Treated Risks mapped into the IRA model; and
  - Subtract the IRA ranged model risk (Inherent Risk) from the Project Delivery (Systemic) Risk generated by the Parametric Method for each of schedule & cost
- This enables risk optimisation, ranking of risk drivers and realistic schedule and cost distributions based on past project performances

P+IRA Methodology

- The following graphic shows the combined P+IRA methodology



Hybrid P+IRA – experience to date

- RIMPL has used this methodology on three quite different projects to date:
  - A minerals processing megaproject
  - A Natural Gas Plant brownfields debottlenecking project
  - A biologicals pharmaceutical project (in progress) that is equivalent to a megaproject in scale and complexity
- The combination has been successful:
  - Systemic risk distributions for schedule and cost increase the spread between P10 and P90 significantly, increasing the modelling realism
  - Increase in cost spread has been particularly helpful, producing credible contingency levels at P50 and possible management reserves at higher P values
  - Systemic Risk Inputs Workshop discussions are valuable in raising awareness of factors affecting the systemic risk uncertainty
  - The Parametric Model provides a “Spider Diagram” ranking the relative importance of inputs as drivers of systemic risk

For more information:

- For more about John K Hollmann and Hybrid Parametric+Expected Value methodology, go to Validation Estimating Website: www.validest.com
- For more about Risk Integration Management, go to www.riskinteg.com
- For information about AACE International and its Recommended Practices, go to https://web.aacei.org
- For information about the Australian Cost Engineering Society ACES (AACE International's Australian Section), go to www.costengineer.org.au