Project Controls Expo – 13th Oct 2015
Emirates Stadium, London

Introduction to Project Cost and Schedule Risk Analysis

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About the Speaker: Keith Gray

- Consultant and trainer on risk processes (Management _of_Risk) and tools (Predict! Risk Controller, Predict! Risk Analyser, Primavera Risk Analysis, Primavera P6 Risk Register)
- Implementer of ISO 31000 process
- Many sectors covered, including defence, energy, oil and gas, telecomms, ICT, construction
- Established quantitative risk analysis capability in an energy utility
- Early experience in defence during Defence Procurement game changing period
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Agenda

- A few questions
- Processes
- Definitions
- Uncertainty
- Risk discussion
- ISO 31000 process steps
- Recording risks
- Configuring a risk matrix
- Monte Carlo sampling
- Integration
- Typical outputs
- Further discussion points

Project Cost and Schedule Risk Analysis

- A few familiar questions …
  - What?
  - Why?
  - When?
  - How?
  - Where?
  - Who?

Project Cost and Schedule Risk Analysis– What, Why and When

- **What –** realistic, timely, accurate information on project duration and costs taking account of uncertainties and risks
- **Why –** projects are probabilistic in nature and risk analysis information can help set realistic cost and timescales
- **When –** as required through the project lifecycle, for setting budgets and timescales and contingency before execution phase and to aid project controls during execution

Project Cost and Schedule Risk Analysis– How, Where and Who

- **How –** Monte Carlo sampling on estimates of project cost and task duration with uncertainty; risks with estimates of probability and impact linked to costs and tasks; qualitative level of risks from a configured risk matrix, aggregated cost and duration from Monte Carlo simulation
- **Where –** cost and planning tools; risk database; Monte Carlo simulation tool; import / export interfaces
- **Who –** estimators, schedulers, risk analysts, project team, project managers, decision-makers

Risk Management Processes

- Processes
  - ISO 31000 Risk management – Principles and Guidelines
    - plus ISO Guide 73:2009, Risk Management – Vocabulary and ISO/IEC 31010, Risk Management – Risk Assessment Techniques
  - Management_of_Risk: Guidance for Practitioners
  - PMBoK, Section 11, Project Risk Management
  - APM BoK, Section 2 .5 Project Risk Management
    - plus Project Risk Analysis & Management, (2004) 2nd edition

Definitions - Risk

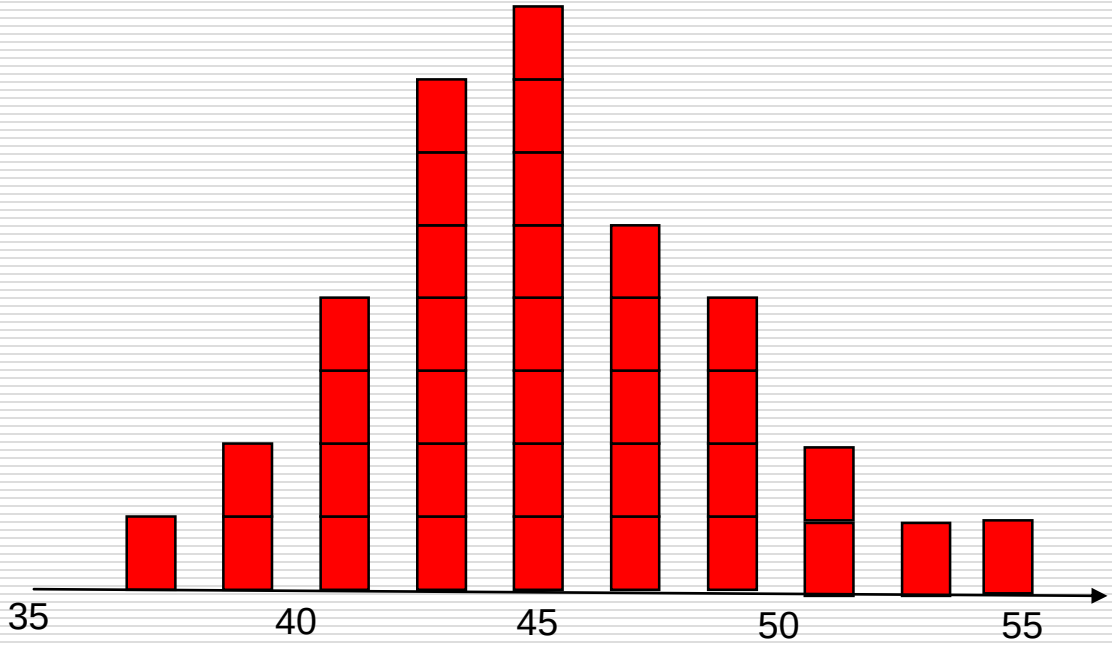
- ISO 31000: “Effect of uncertainty on objectives”
- M_o_R: “An uncertain event or set of events that, should it occur, will have an effect on the achievement of objectives. A risk is measured by a combination of the probability of a perceived threat or opportunity occurring and the magnitude of its impact on objectives.”
- PMBoK: ”An uncertain event or condition that , if it occurs, has a positive effect on a project’s objectives.”
- APM: (Risk event) “An uncertain event or set of circumstances that should it or they occur would have an effect on the achievement of one or more of the project objectives.”
- APM: (Project risk) “The exposure of stakeholders to the consequences of variation in outcome.”

Discussion of terms in the definitions

- Uncertainty
- Objectives
- Uncertain event
- Probability (also known as likelihood or chance)
- Perceived threat or opportunity
- Magnitude of impact
- Exposure
- Variation in outcome
- Stakeholders

Illustration of uncertainty - journey to work

- **Plan** to go from same place to work every day
- How long does it take? Best time? Worst time? Most likely?
- Pattern over time might look like this -



Uncertainty discussion points

- Why the variation? Ask the audience!
- Pattern is also known as: “frequency distribution shape” or “probability distribution function”
- Uncertainty in a project schedule relates to the variation in an estimate of a task’s duration and / or cost so need skilled estimators for quality
- What drives the variation in a project? What assumptions are made?
- How do we make use of this variation? Ask the audience!
- Use three-point estimating for each task to define best, worst and most likely durations with a defined distribution shape
- Monte Carlo sampling to provide
  - Likelihood of achieving project finish date / duration &cost
  - Drivers of project duration and project cost

Example of Monte Carlo sampling

- Example – From morning alarm going off to arrival at desk at work

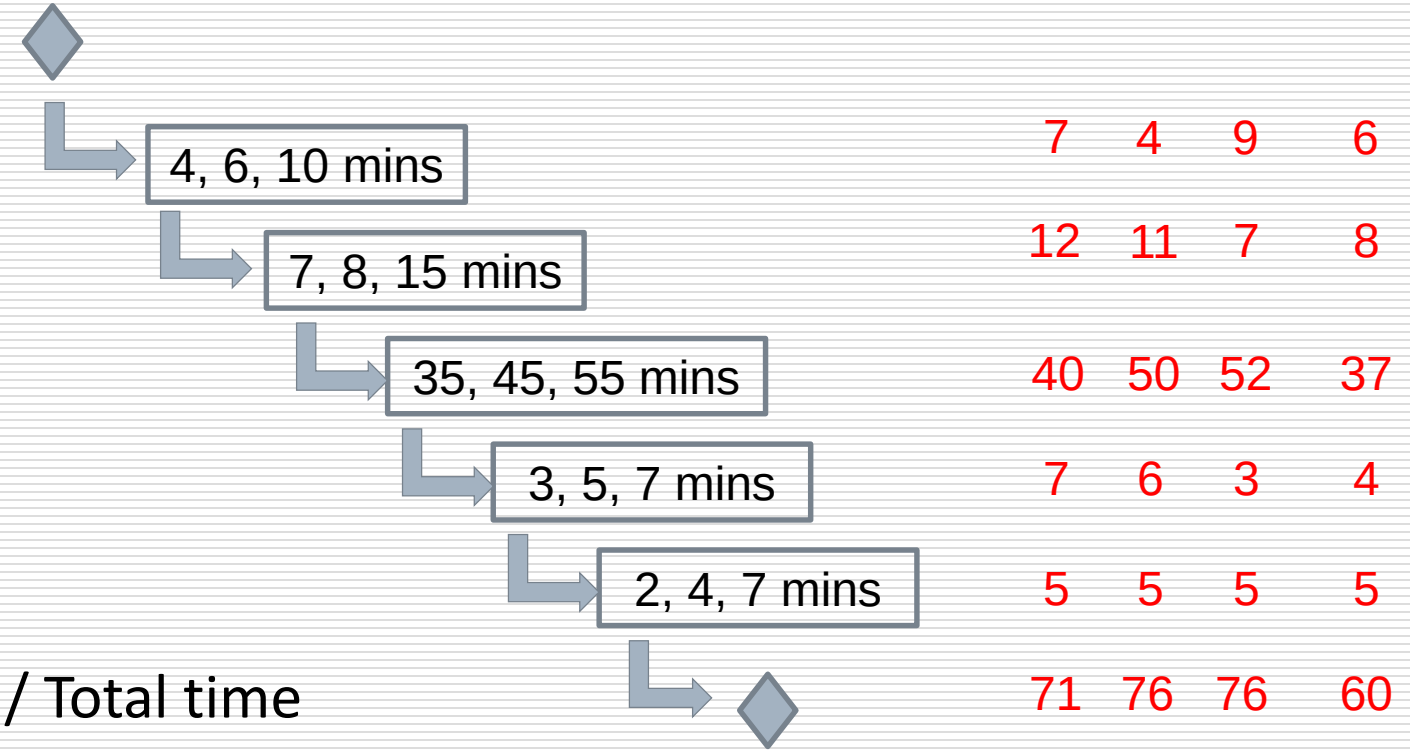
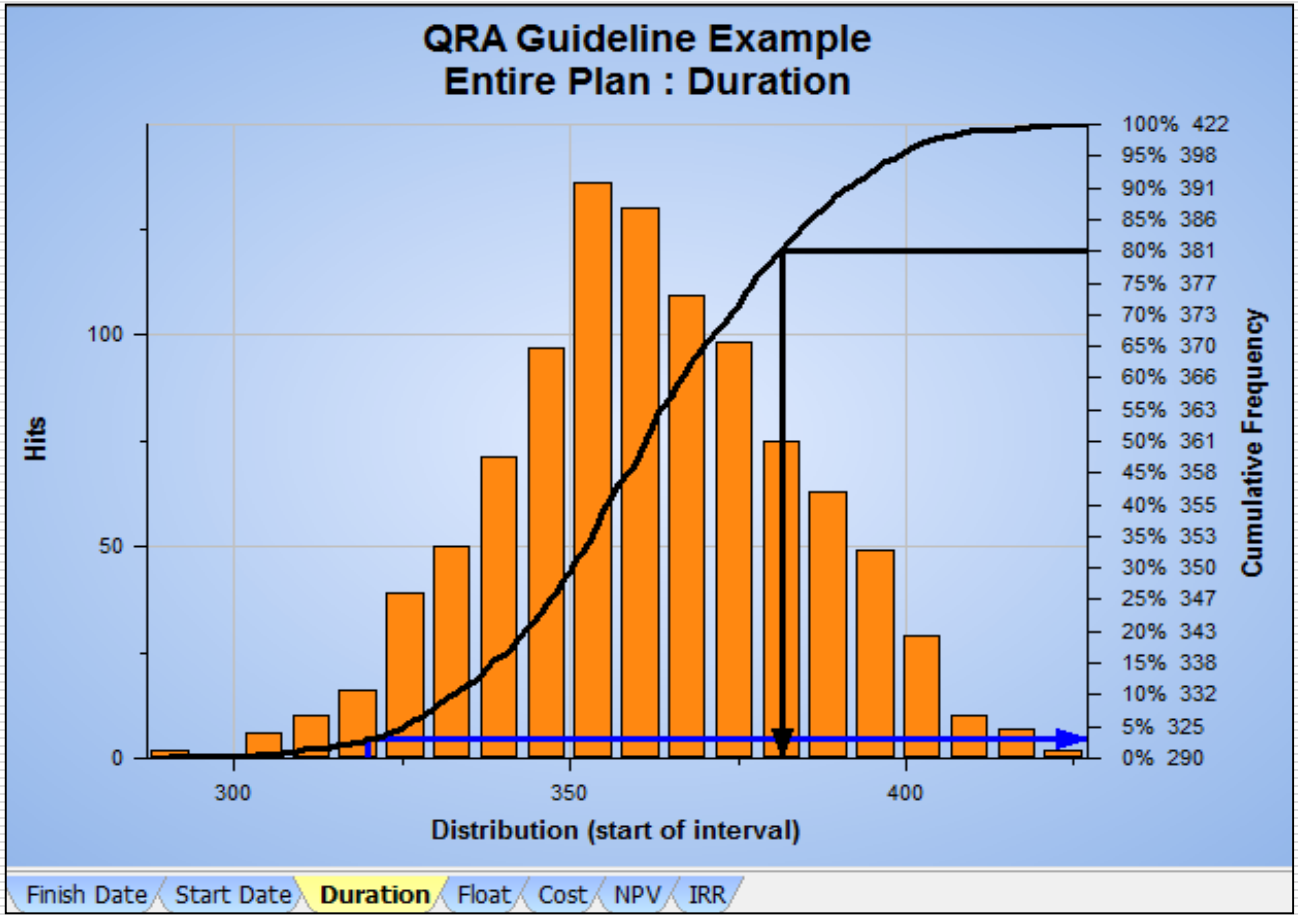


Illustration of Monte Carlo sampling - duration



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Risk discussion points 1

- Uncertain event – may or may not occur
- Likelihood of occurrence is also known as probability, measured as a decimal 0 to 1 or percentage 0% to 100%
- If 0 or 0%, then there is no risk
- If 1 or 100% there is no risk as has occurred & should be treated as an issue
- Threat – if risk occurs,
  - schedule **could** be extended, and / or
  - cost will be increased
- Opportunity – if it occurs,
  - schedule **could** be reduced, and / or
  - cost will be reduced (if cost of managing less than benefit)

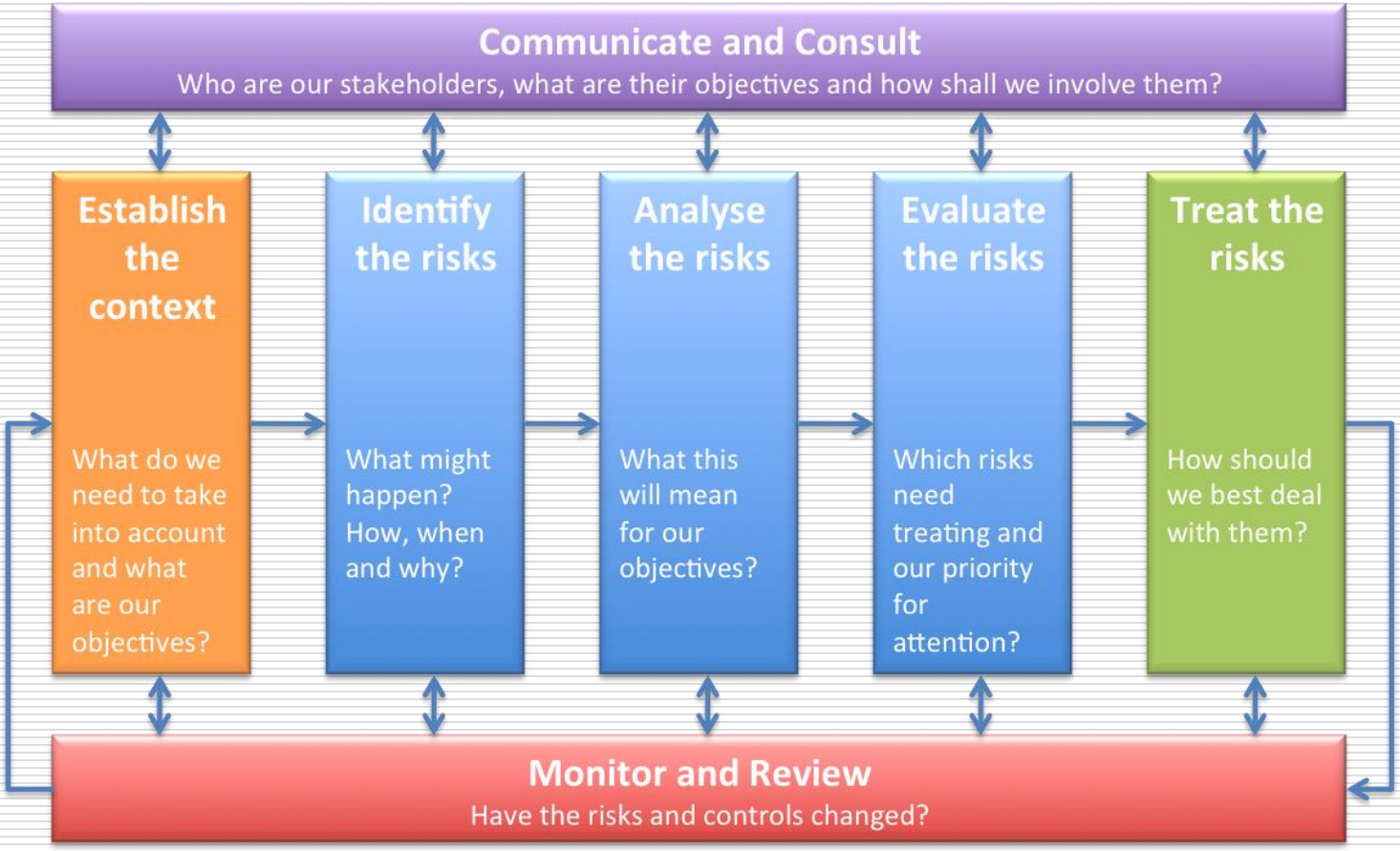
Risk discussion points 2

- Magnitude of impact: days added to (or subtracted from) task duration and / or costs added to (or reduced from) task cost
- There can be
  - one risk impacting several tasks
  - one task impacted by several risks
  - several risks impacting several tasks
- To measure the full impact of a risk it must be linked to an appropriate Work Breakdown Structure element(s) (Project, Task package, Task)
- Impact may be uncertain (best, worst, most likely so need three-point estimate) or certain (single value, such as a fee)

Risk discussion points 3

- Exposure is the full range of the variation of project outcomes over the cumulative probability range from 0% to 100%, shown as ‘S’ curve in earlier slide
- Use can be made of ‘S’ curves for setting budgets and timescales, including contingency
- Stakeholders – “Any individual, group or organisation that can affect, be affected by, or perceive itself to be affected by an initiative (project or task).” Source Management_of_Risk
  - Task managers, project managers, decision-makers, investment committee, residents, landowners, schools, emergency services, etc etc

ISO 31000: Risk management – Principles and Guidelines, Process Steps



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ISO 31000 Risk process steps 1

- Establish the context – everything you need to know about the project, including objectives and stakeholders. Need to keep this under review
  - Project charter should define how risk are to be managed – qualitatively, quantitatively or both
- Identify the risks – what may happen. Use construct <Cause>, <Event>, <Impact or consequence> for clarity
- Analyse the risks - in terms of likelihood and impact on objectives, taking account of current controls and their effectiveness
  - Impacts on objectives can be readily quantifiable (cost and duration) or non-quantifiable (quality, reputation, legal and compliance, health and safety, environment)
  - Ranges of likelihood and impacts and impact types should be defined in project charter or organisation risk policy / standard

ISO 31000 Risk process steps 2

- For each risk, the highest of the impact types are combined with likelihood to determine a risk level or score.

- Evaluate the risks - sorted from highest likelihood and impact to lowest likelihood and impact. Levels or scores can be used
- Treat the risks - focuses attention on the prioritised risks and can use one or more of these options:
  - Avoid (Enhance) – remove the risk by changing the plan or circumstances
  - Treat – proactive action to reduce (increase) likelihood and / or reduce (increase) impact
  - Share – with another party including contracts and insurance
  - Accept – an informed decision to do nothing but keep under review

ISO 31000 Risk process steps 3

- The decision to proceed with treatment options should take into account cost effectiveness, timing, resourcing
- Effectiveness can be measured as the difference between the pre-treatment and planned post-treatment levels or exposure for the cost of the treatment actions and the cost of treating any secondary risks introduced by the actions.
- Communicate and consult - throughout the risk lifecycle
- Monitor and review - throughout the risk lifecycle
- Contingency can be recommended based on the difference between the pre-treatment and planned post-treatment values at an agreed confidence level

Risk identification exercise

- Exercise. Look at the journey to work example. Look at one of the tasks and identify at least 2 risks.
- Use the construct <cause>, <event>, <impact> to describe the risk
- How likely is the risk to occur? How much will it impact on my journey?
- What can you do about the risk?
- What assumptions have you made?

Practical aspects: Recording risks - database or spreadsheet?

- What do we need a risk database to be capable of?
- Does a spreadsheet achieve these features?
- What do you use?

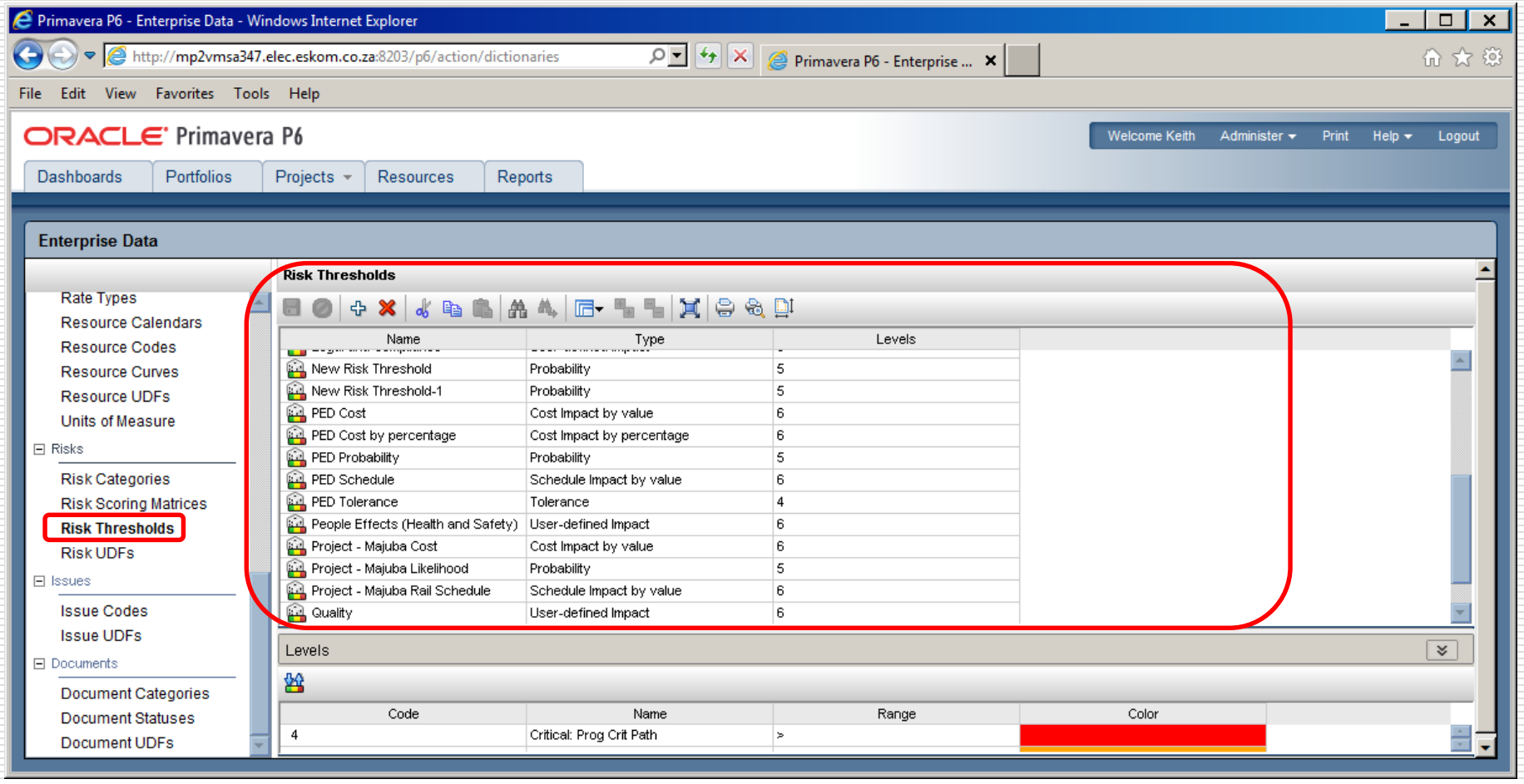
Practical aspects: Risk databases

- What do we need a risk database to be capable of?
  - Accessible
  - User profiles
  - Controlled configuration to a process / standard / project / organisation
  - Ease of use and secure
  - Handle pre-treatment and planned post-treatment assessments
  - Audit trail
  - Reporting
  - Roll back / backed up
  - Integrate with other tools and link risks to tasks / cost elements
  - Comply with IT policy

Example configuration requirement for risk matrix in database

- Level of risk using a risk matrix by combining highest impact (or consequence) with probability(or likelihood) (also known as heat map)
- Project impact types from organisation standard (e.g. commonly 4, 5 or 6; cost, schedule delay, reputation, environment, people, legal)
  - Impact ranges - how many and how labeled
  - Examples: 1, 2, 3, 4. 5, 6; Very Low, Low, Medium, High, Very High;
- Probability ranges from organisation standard
  - Probability - how many and how labeled (commonly 4, 5 or 6)
  - Examples: e.g. A, B, C, D; V Low, Low, Medium, High, V High;
- Risk bands (or tolerance threshold) from organisation standard
  - Risk bands – how many, how labeled and field colours
  - Examples: Low, Medium, High; Levels I, II, III, IV

Example configuration settings



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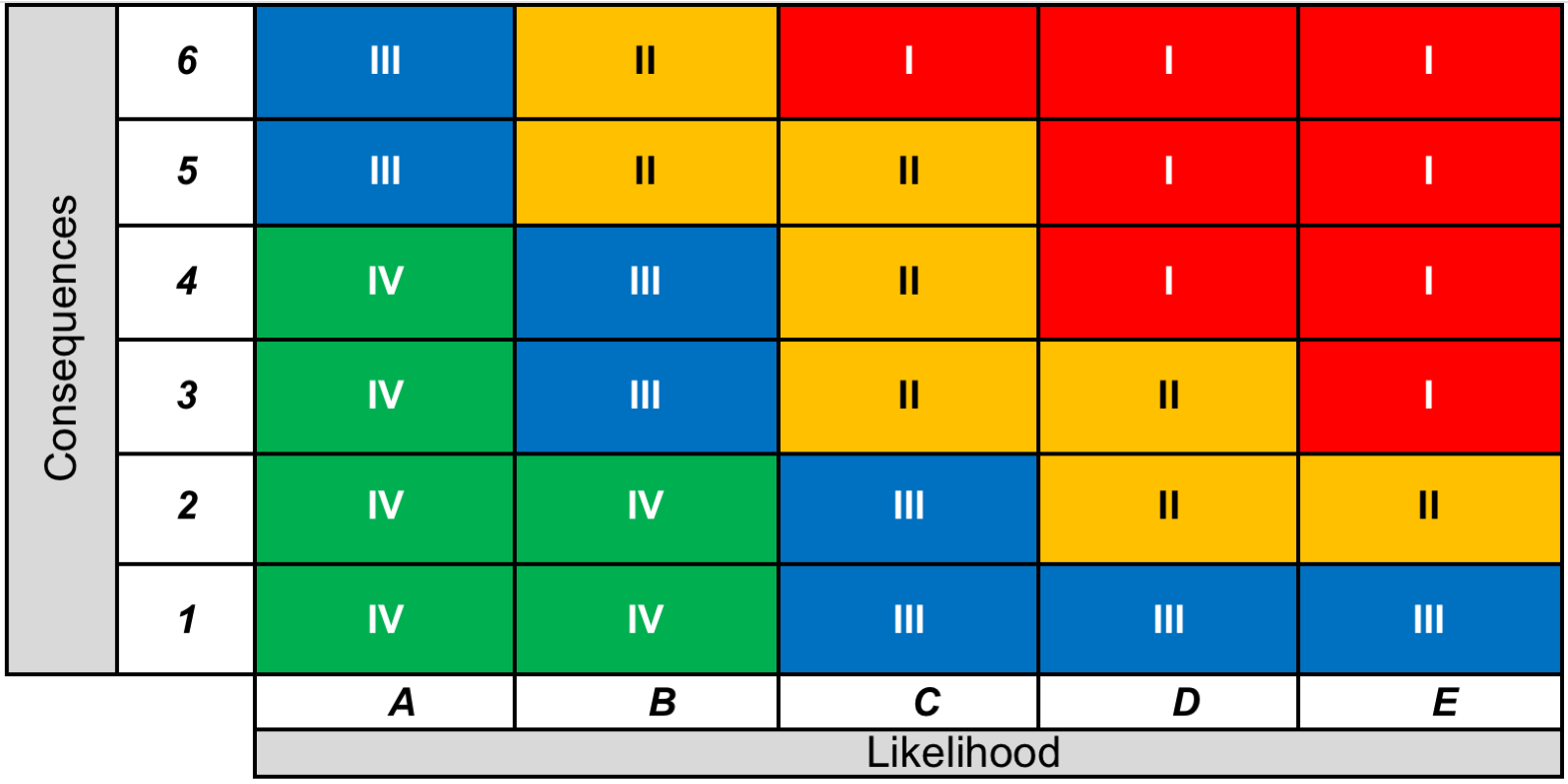
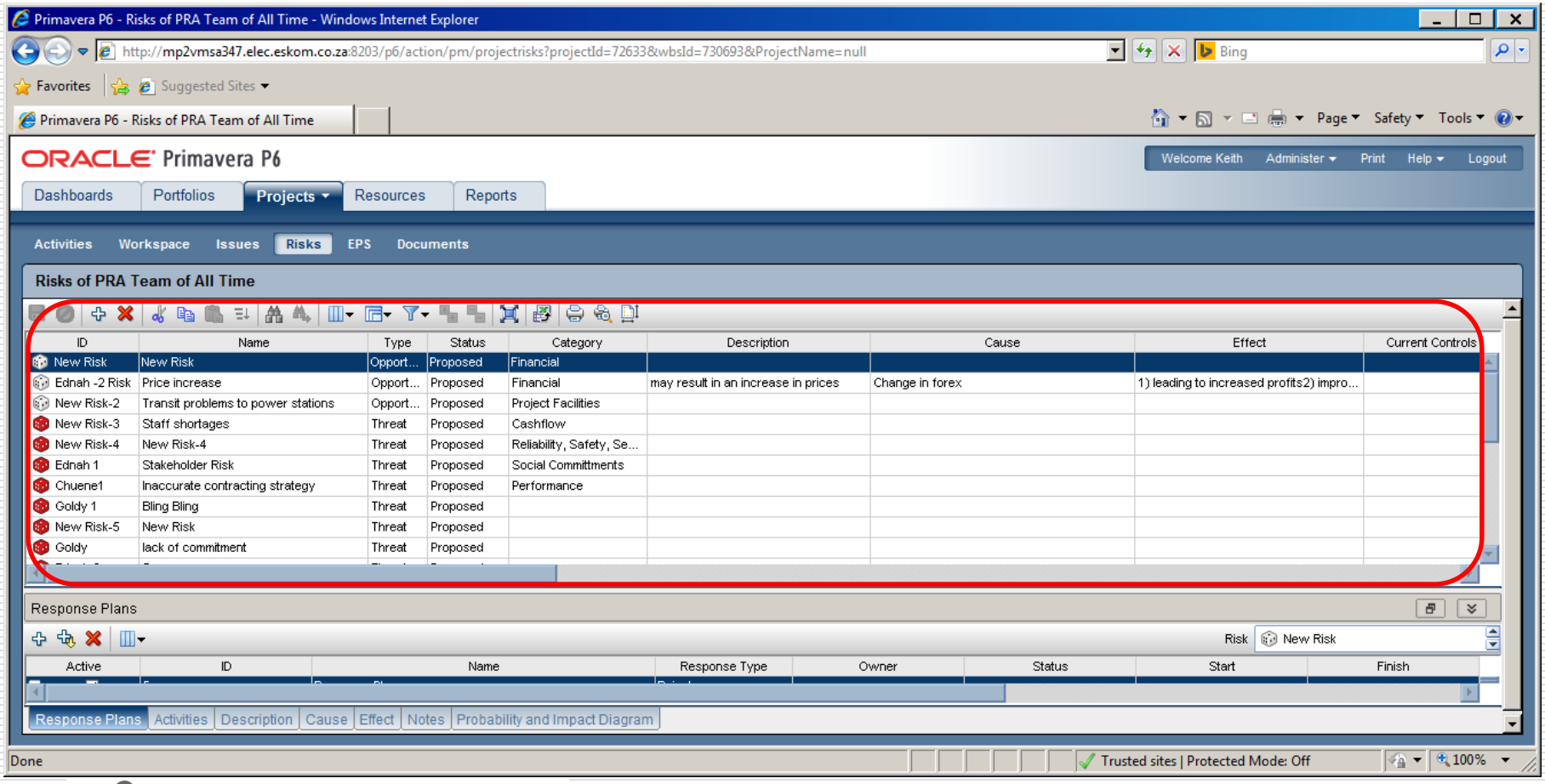
Example configured risk matrix



Identify the risks



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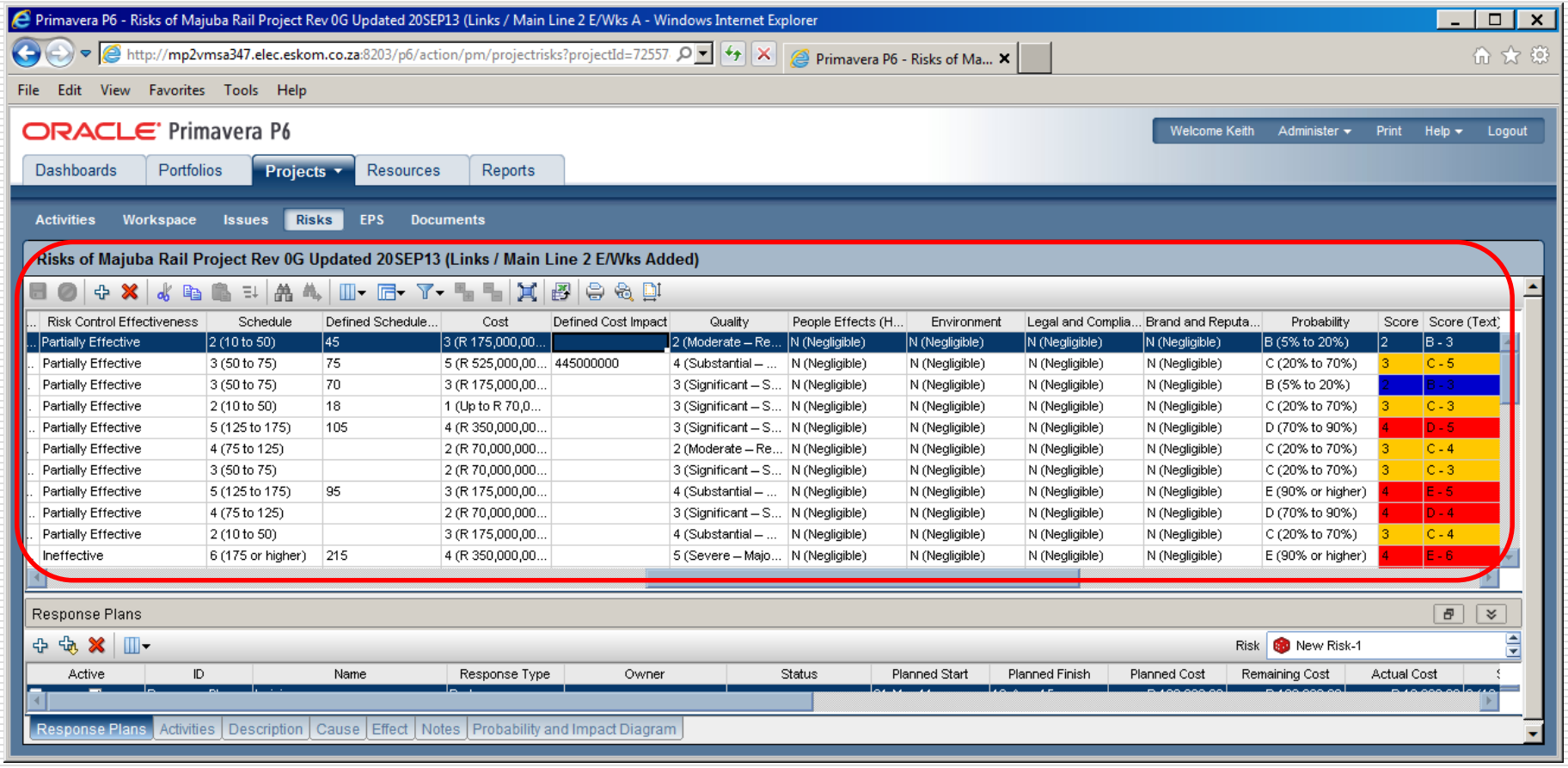
Analyse the risks



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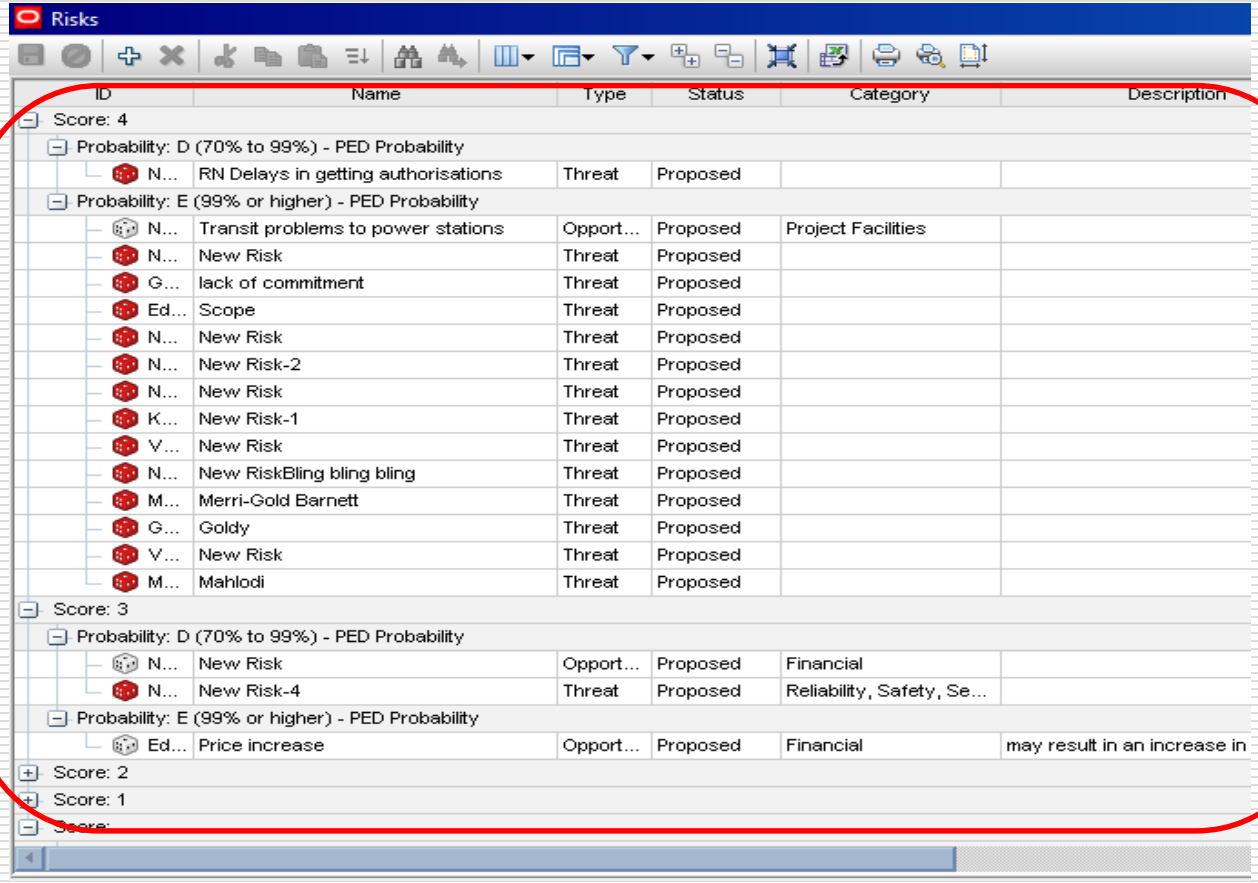
Evaluate the risks



ID	Name	Type	Status	Category	Description
Score: 4					
Probability: D (70% to 99%) - PED Probability					
N...	RN Delays in getting authorisations	Threat	Proposed		
Probability: E (99% or higher) - PED Probability					
N...	Transit problems to power stations	Opport...	Proposed	Project Facilities	
N...	New Risk	Threat	Proposed		
G...	lack of commitment	Threat	Proposed		
Ed...	Scope	Threat	Proposed		
N...	New Risk	Threat	Proposed		
N...	New Risk-2	Threat	Proposed		
N...	New Risk	Threat	Proposed		
K...	New Risk-1	Threat	Proposed		
V...	New Risk	Threat	Proposed		
N...	New RiskBling bling bling	Threat	Proposed		
M...	Merri-Gold Barnett	Threat	Proposed		
G...	Goldy	Threat	Proposed		
V...	New Risk	Threat	Proposed		
M...	Mahlodi	Threat	Proposed		
Score: 3					
Probability: D (70% to 99%) - PED Probability					
N...	New Risk	Opport...	Proposed	Financial	
N...	New Risk-4	Threat	Proposed	Reliability, Safety, Se...	
Probability: E (99% or higher) - PED Probability					
Ed...	Price increase	Opport...	Proposed	Financial	may result in an increase in
Score: 2					
Score: 1					
Score:					

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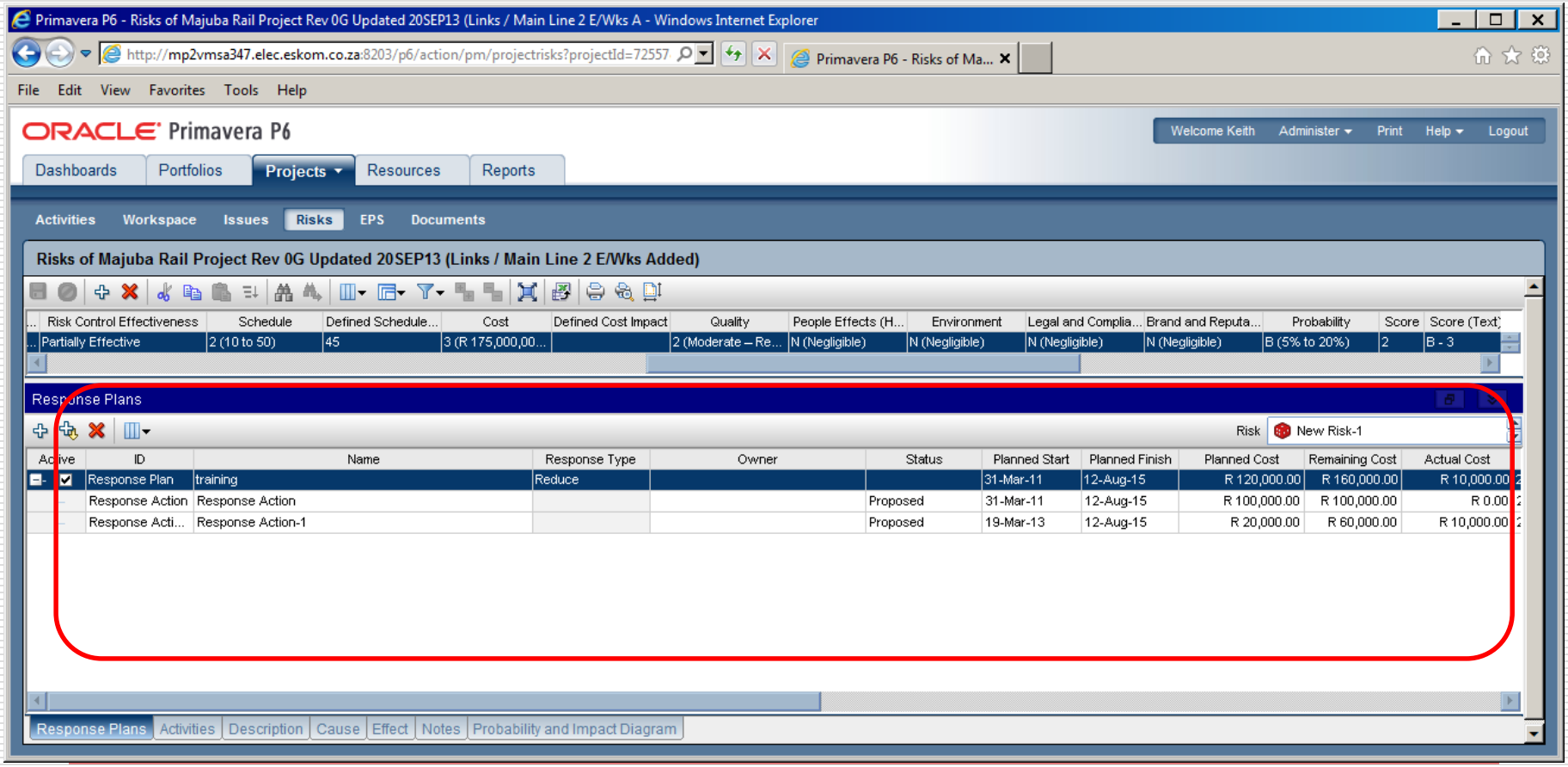
Treat the risks 1



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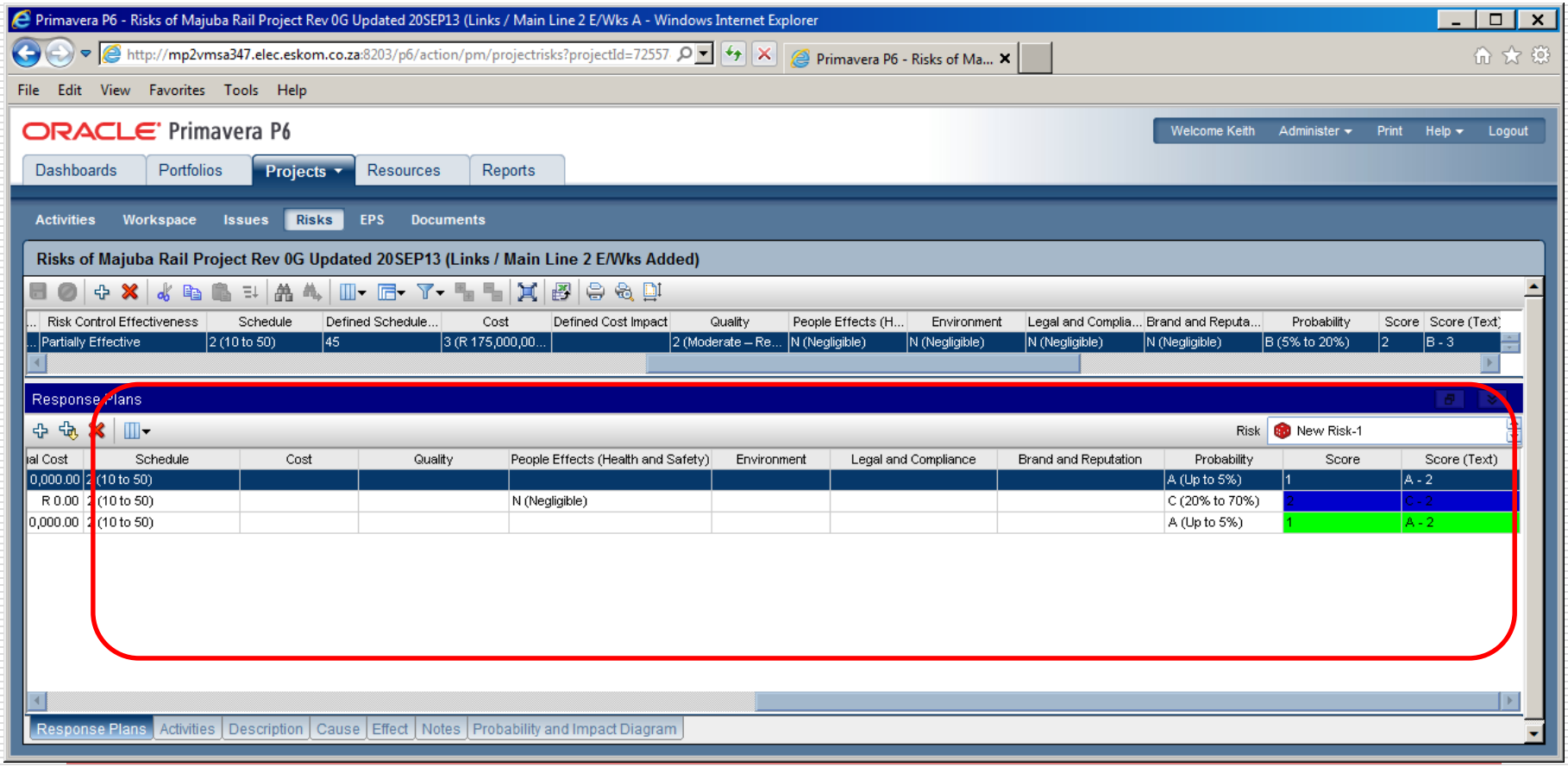
Treat the risks 2



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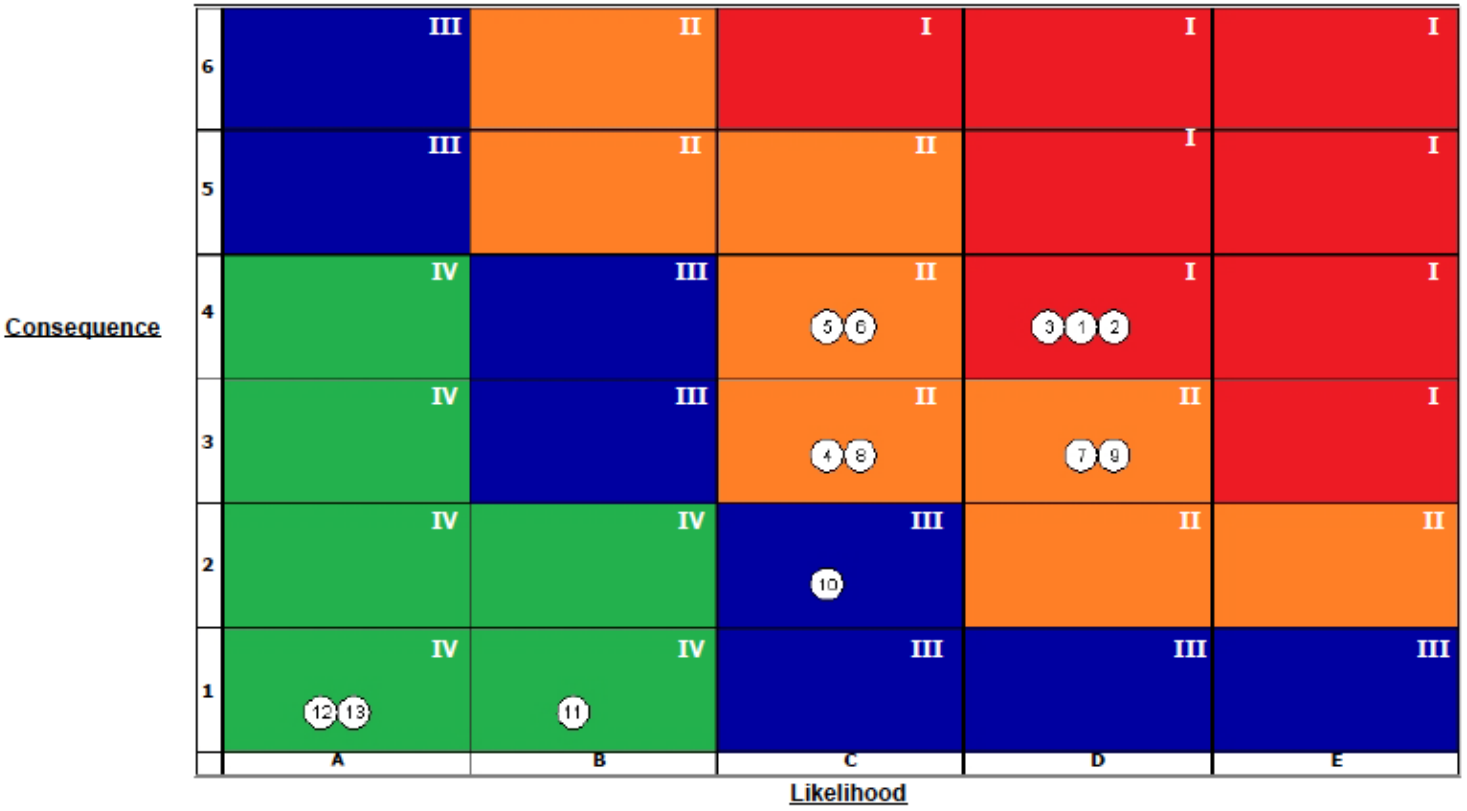
Example populated risk matrix



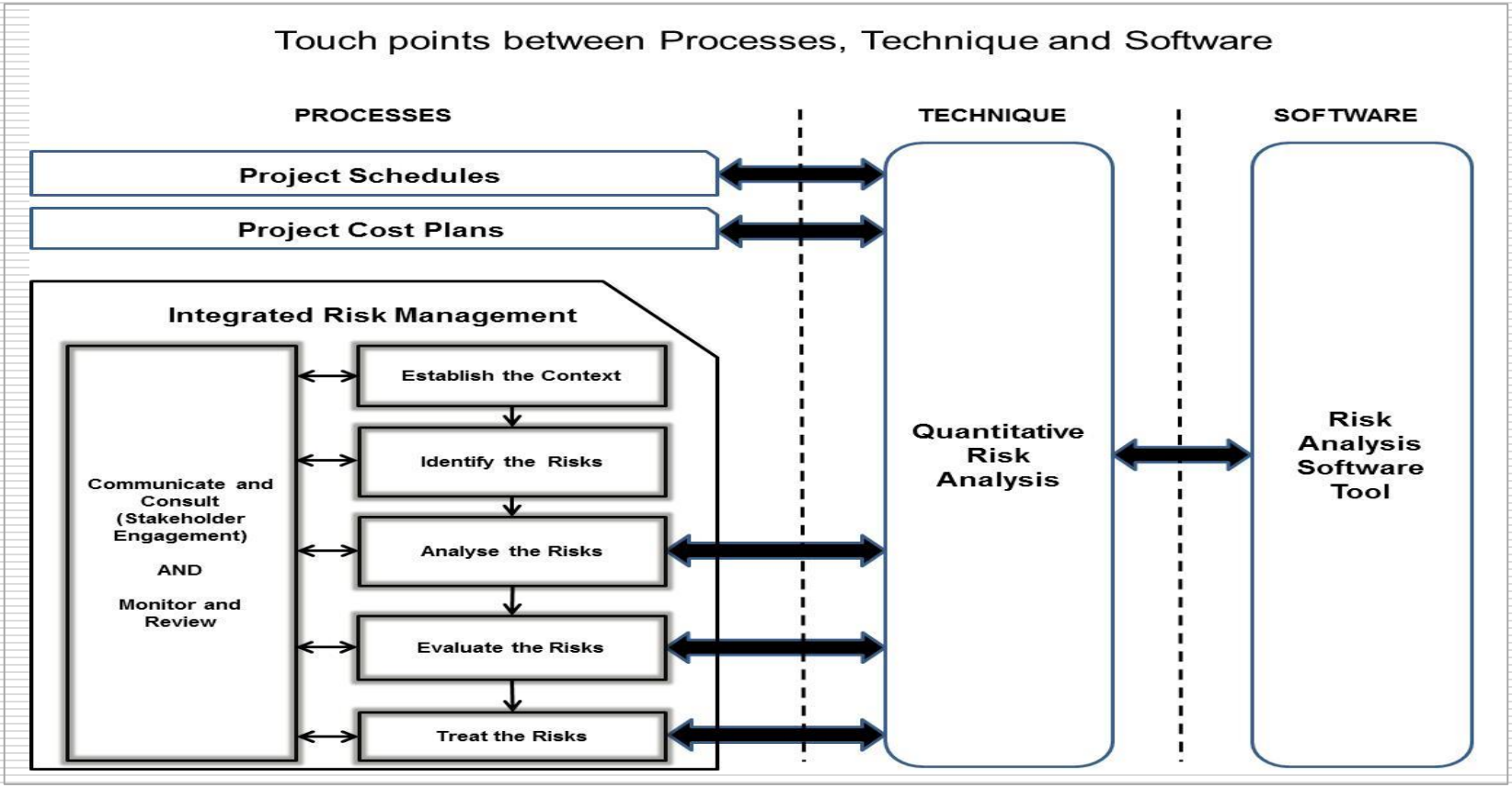
Risk database vs Monte Carlo sampling

- Risk matrix used for qualitative analysis so that risk levels can be compared
- What are the benefits and limitations?
- Benefits: Intuitive; easy to understand and prioritise risks
- Limitations: Difficult to aggregate; can be misleading if risk linked to task in schedule, cannot distinguish between risks impacting in a schedule
- Monte Carlo sampling pinpoints drivers of uncertainty and risks, both cost and schedule; aggregates all risks to provide total exposure
- Let's have a look at what else the Monte Carlo sampling tool should be capable of

Monte Carlo sampling

- What do we need Monte Carlo sampling to be capable of?
- Import schedule and cost plan if separate
- Edit uncertainty values, distributions shapes and correlation
- Import risks from risk database
- Link risks to tasks and cost elements if not already linked in database
- Edit cost and schedule impact values
- Edit risk probability
- Edit risk distribution shape
- Select number of iterations
- Show histograms and pre & post treated cumulative probability graphs
- Show schedule and cost drivers with and without pre & post risks
- Reports

Integration with Quantitative Risk Analysis tool



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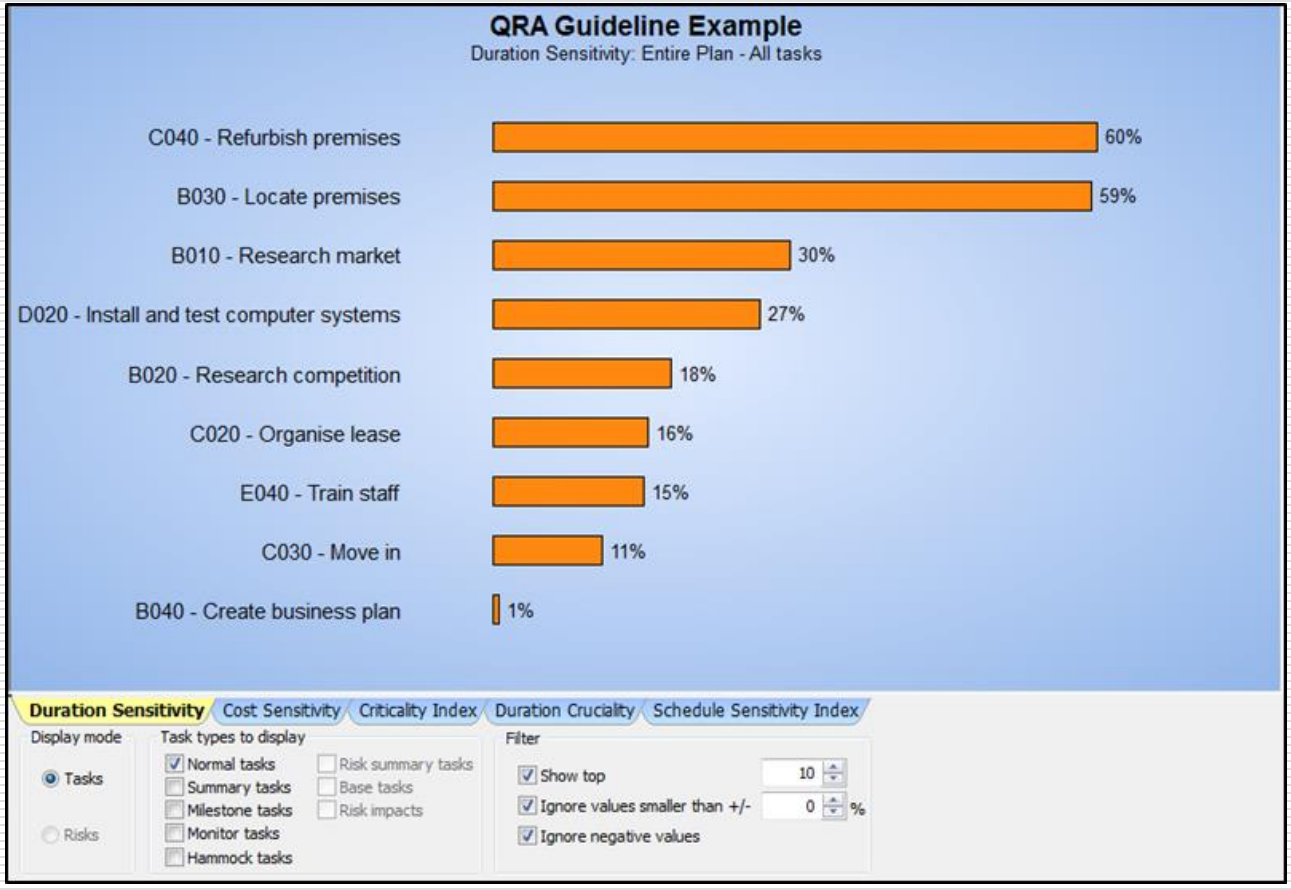
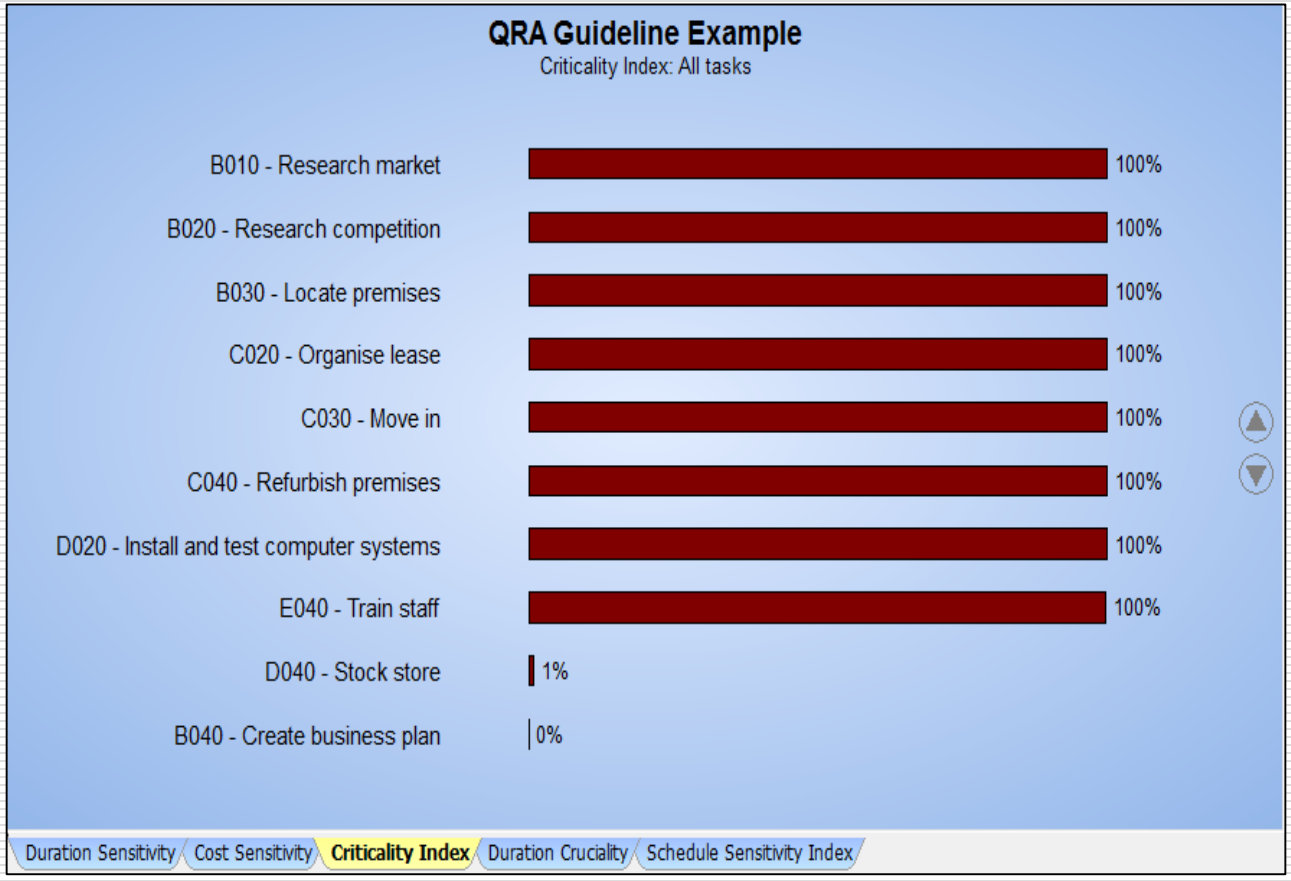
Typical outputs – Tornado graph, schedule duration drivers: duration sensitivity



Typical outputs – Tornado graph, schedule duration drivers: criticality index



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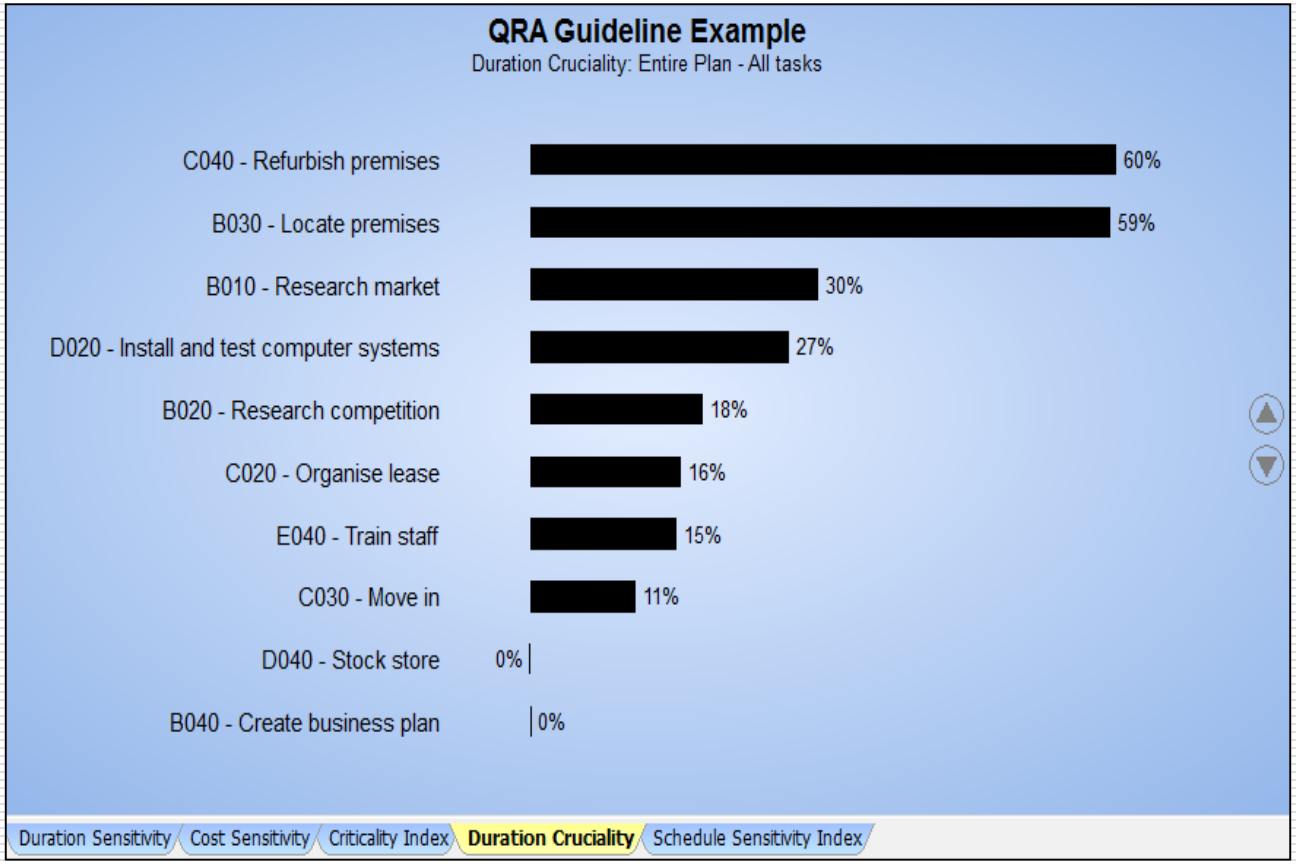
Typical outputs – Tornado graph, schedule duration drivers: duration cruciality



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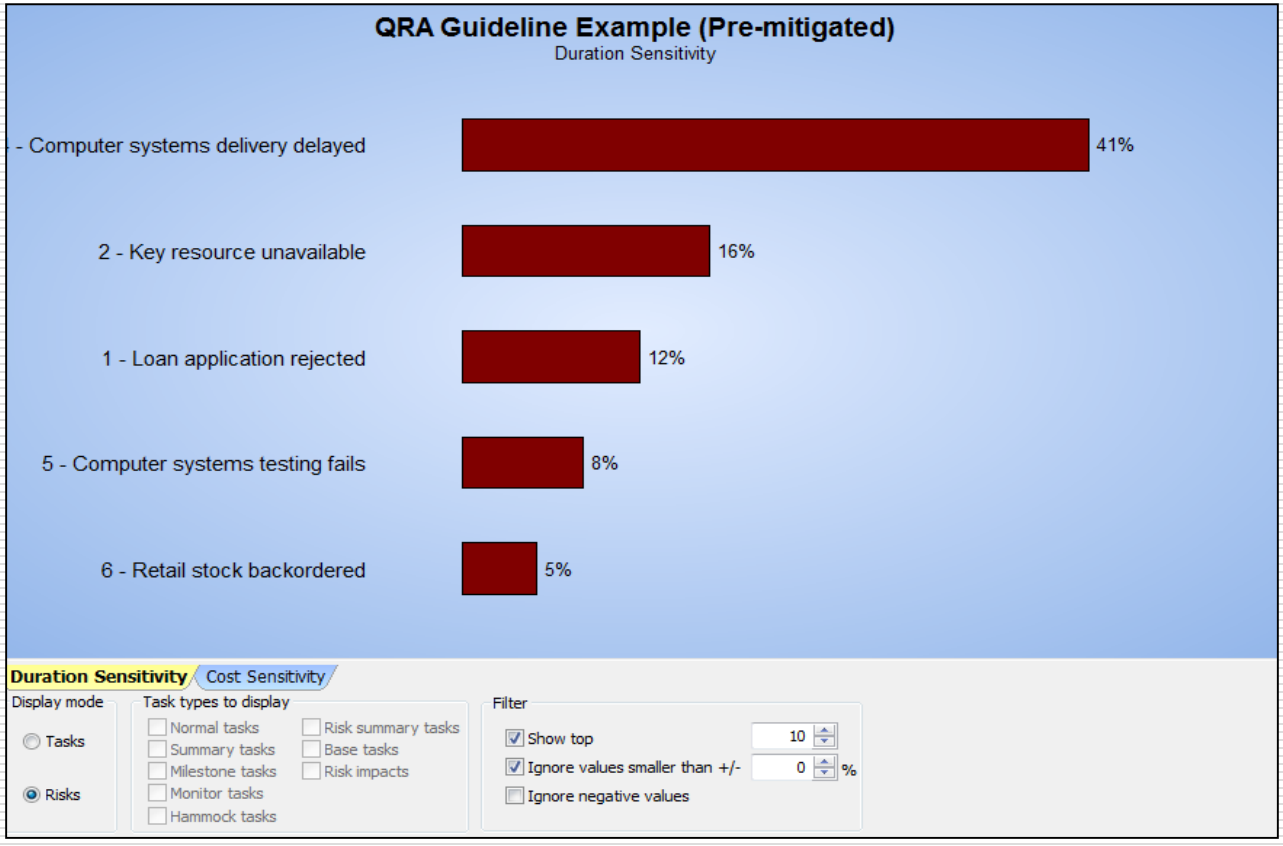
Typical outputs – schedule duration pre-treated risk drivers: duration sensitivity



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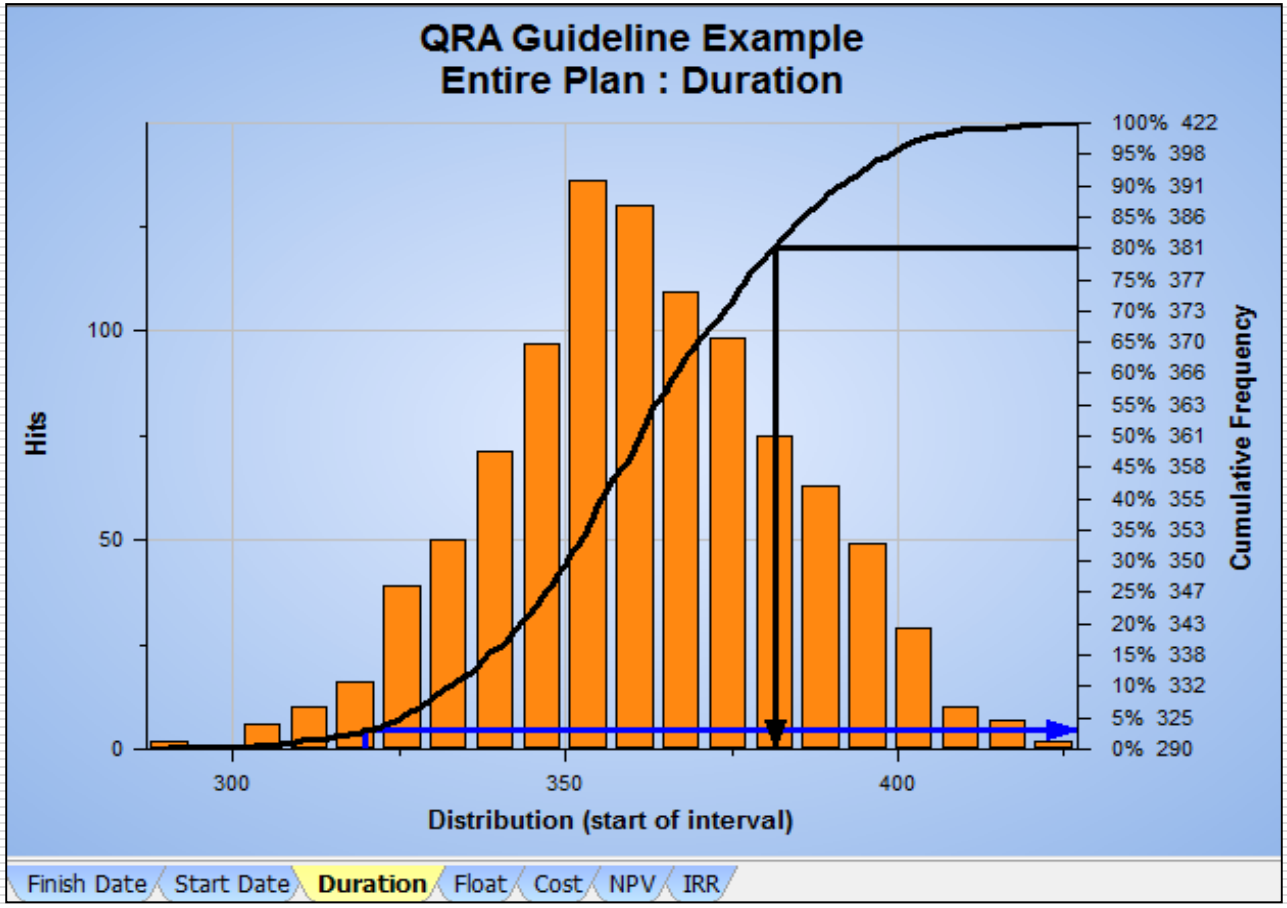
Typical outputs – frequency histogram and cumulative probability: duration uncertainty



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Further discussion points

- Use of the analysis graph for contingency determination
  - Benefits – Ranges of outcomes address probabilistic nature of projects; many what if scenarios and options can be explored; can support earned value and cost to completion forecasts
  - Limitations – only modeling those risks identified; new risks will emerge during execution so need to repeat frequently
- Skills of everyone involved – Ask the audience!
  - Estimators and schedulers: do you use three-point estimating?
  - Risk practitioners: how thorough is risk identification
- Do you or your projects use Monte Carlo sampling? Ask the audience!
- Do project managers use qualitative and / or quantitative risk analysis?

Thank you

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