# Project Controls Expo - 31st Oct 2012
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## Calculating and Defending Cost Contingency using Rational Risk Models

# About the Speaker

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10 years Project Manager in DPA/DE&S (MOD)

5 years Principal Consultant (HVR Consulting/QinetiQ )

Specialisms

- Risk Management Improvement Programmes
- Quantitative Risk Analysis/Modelling
- Developing risk based solutions to decision making

# CONTENT

Context

Calculating and justifying cost contingency during bid development

- Why Bother with Cost Risk Modelling
- Bad and good cost risk modelling practice
- Multi pass approach to risk modelling
- Improving Risk Inputs
  - Risk descriptions
  - Risk estimates
  - Risk ownership

Cost Risk Modelling during bid development – Get it right

# WHY BOTHER?

# Typical Bid/Price Release Questions

1. Can we Win?
2. Can we deliver?
3. Will we make a profit?

An enthusiastic bid team will always answer YES to all 3.

3. What % confidence do you have achieving target margin?

3a. Show me how you came to that figure

# Observations

- Bidding stage is often the time we are most uncertain about a project's final cost
  - Little structured time is often devoted to understanding this uncertainty
  - Organisations lose money because of this.

- Contingency is often removed because we cant defend it
  - Bid Reviews
  - Customer intervention

- Key to defending contingency
  - High quality risk descriptions and estimates
  - A well thought out and logical cost risk model
  - Clear understanding of risk ownership

# We're all really good at estimating cost!

HUMBER BRIDGE

- Original Cost Estimate (£28M)
- Final Cost (£151M)

JUBILEE LINE

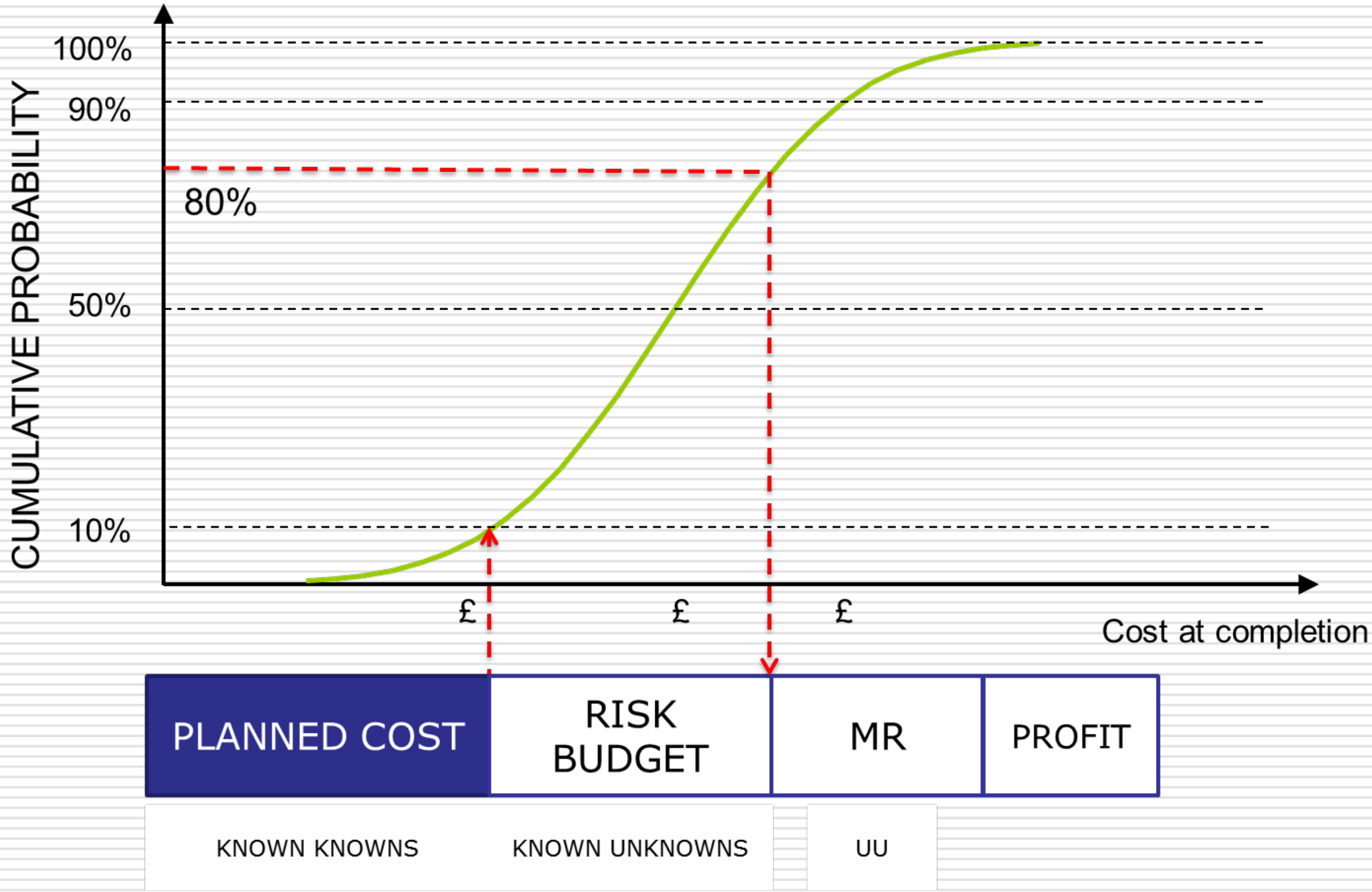
- Original Cost Estimate (£1.5Bn)
- Final Cost (£3.5Bn)
- 2 years late

# Be complacent at your peril.....

...."Risk budget? We always just add 10% to the base cost, oh and Management Reserve that's just another 5%....."

This nameless company lost ~£10million on a single project. Their original price was £15m. Final cost £25m.

# Cost Risk Modelling Output



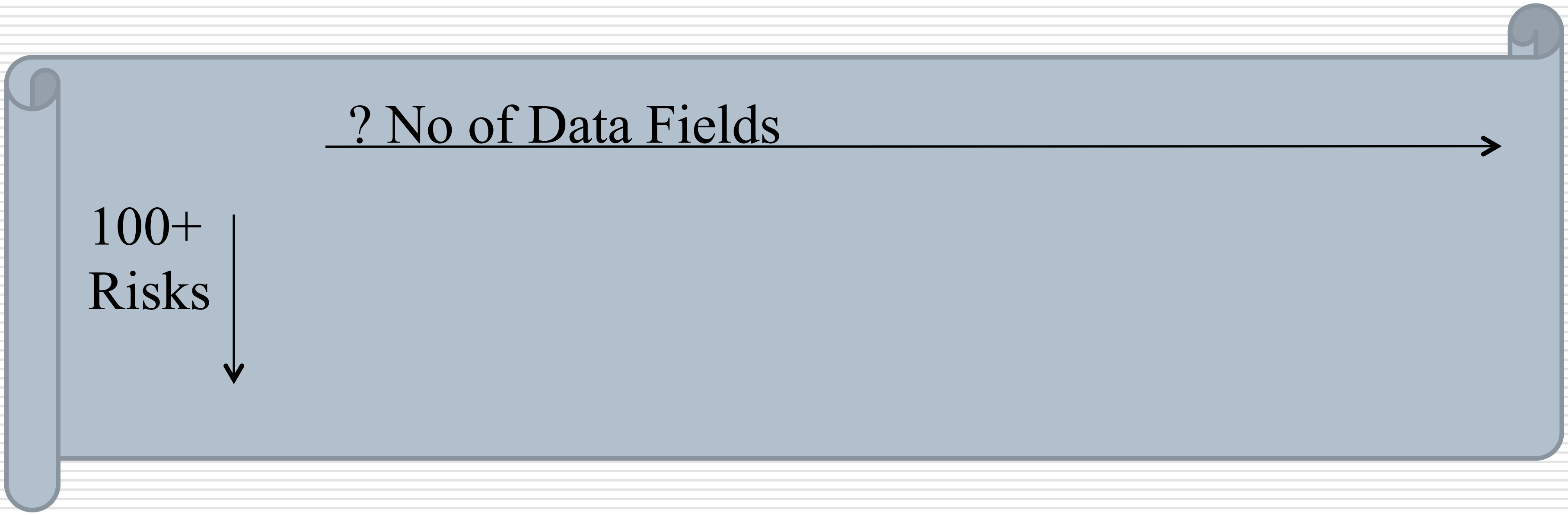
Cost Risk Modelling

# GETTING IT RIGHT

# 3 STEPS TO SUCCESSFUL RISK MODELS

- 1. KNOW WHAT BAD LOOKS LIKE
- 2. KNOW WHAT GOOD LOOKS LIKE
- 3. FOLLOW A STRUCTURED AND AUDITABLE APPROACH TO THE DEVELOPMENT OF
  - MODEL STRUCTURE
  - RISK INPUTS TO THAT MODEL
  - JUSTIFICATION FOR EVERY ELEMENT OF THE MODEL

# BAD INPUTS
## Too Many Risks – Too Many Data Fields

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# BAD INPUTS
## Unfounded Post Mitigation Estimates

### Some typical examples

| | Pre-mitigation | | | Post-mitigation | |
|---|---|---|---|---|---|
| | Prob | Cost | Risk Response | Prob | Cost |
| Risk 1 | 50% | £200k | Monitor progress | 25% | £100k |
| Risk 2 | 70% | £1,000k | Close control of s/w team | 20% | £500k |
| Risk 3 | 60% | £500k | Perform acceptance test | 5% | £500k |
| Risk 4 | 60% | £500k | Agree contract price | 0% | 0 |

Risks 1 and 2 are examples of unfocussed and ineffective actions

BAD STRUCTURE

Assumption: Overall = Sum of the Parts

Risk register with an ad hoc collection of risks

| | Probability | Cost Impact | Factored Cost |
|---|---|---|---|
| Risk 1 | 50% | £200k | £100k |
| Risk 2 | 2% | £5,000k | £100k |
| Risk 3 | 60% | £500k | £300k |
| | | | etc. |
| | | | £4,387k |

A default assumption that overall risk is equal to the sum of the risk in the risk register is usually irrational

# BAD APPROACH
# RISK REGISTER COST RISK ANALYSIS

| Risk | Prob | Min Impact | Most likely Impact | Worst Case Impact | Weighted |
|---|---|---|---|---|---|
| X | 20% | £50K | £100K | £300K | £20K |
| Y | 10% | £20K | £300K | £1.0M | £30K |
| Z | 50% | £200K | £500K | £900K | £250K |
| T | 50% | £10K | £20K | £150K | £10K |
| | | | | Monte Carlo Output | XYZ |

Assumes each risk has a discrete effect
Often fails to take account of covariance/correlation between cost components
Often includes duplications in impact
Often fails to account for secondary risk effects, e.g. marching army
Takes no account of mutually exclusive events
Takes no account of multiplicative effects

## BAD INPUTS
## Ownership of Very Low probability risks

Risk register with an ad hoc collection of risks

| | Probability | Cost Impact | Factored Cost |
|---|---|---|---|
| Risk 1 | 50% | £200k | £100k |
| Risk 2 | 2% | £5,000k | £100k |
| Risk 3 | 60% | £500k | £300k |
| | | | etc. |
| | | | £4,387k |

Should this risk be owned by the project manager?

Very Low Probability – Very High Impact risks would normally be owned by the organisation rather than the project

BAD INPUTS
Lack of thought and attention to detail

A respectable number of risks

1. Risks that have already been more or less managed
2. Risks owned by the customer
3. Risks that would be higher if the project was won by a competitor
4. Risks only included if the customer has mentioned them explicitly
5. Risk estimates designed to keep stakeholders happy

In practice, this approach may help win a project or get it started, but only at the expense of significant downstream difficulties

# What does good look like?

- The Cost Risk Model must
  - Include costs from whole scope of project
  - Be logical, i.e. no duplication, no impossible simulations (mutual exclusivity)
  - Be based on a correct interpretation of the variability risk and risk events
  - Be able to simulate the effects of schedule performance
  - Be able to simulate multiplicative effects
  - Include appropriate correlation of inputs
- Framing assumptions must be captured
- Challenging to get right
- Iterative and Top Down is often the best approach

# Multi Pass -1st Pass

- Simple model based on two point estimates
- Supports the design of the risk model
- Adds up cost components
  - Sum of worst cases
  - Sum of best cases
- Can be used to identify what carries little/greatest risk, i.e. small/large delta between best and worst case
- In order to develop estimates key risks can be identified that can be missed with bottom up cost models
- Can be used to capture where costs correlate, i.e schedule slippage as a consequence of contractor performance correlates to project management costs

# Multi Pass – 2nd Pass

- Second Pass – Informed from the 1st pass
  - Structure
    - Rational – reflect the likely behaviour of the project
    - Additive Costs
    - Estimation uncertainty
    - Risk events
    - Calculations for multiplicative effects
    - Correlation between components
    - Logic to avoid impossible slices
  - Monte Carlo Simulation (project rehearsal)
  - No one size fits all
  - Take care when using templates and tools
- Evidence
  - Collate justification for model design and all inputs

# Step by Step example

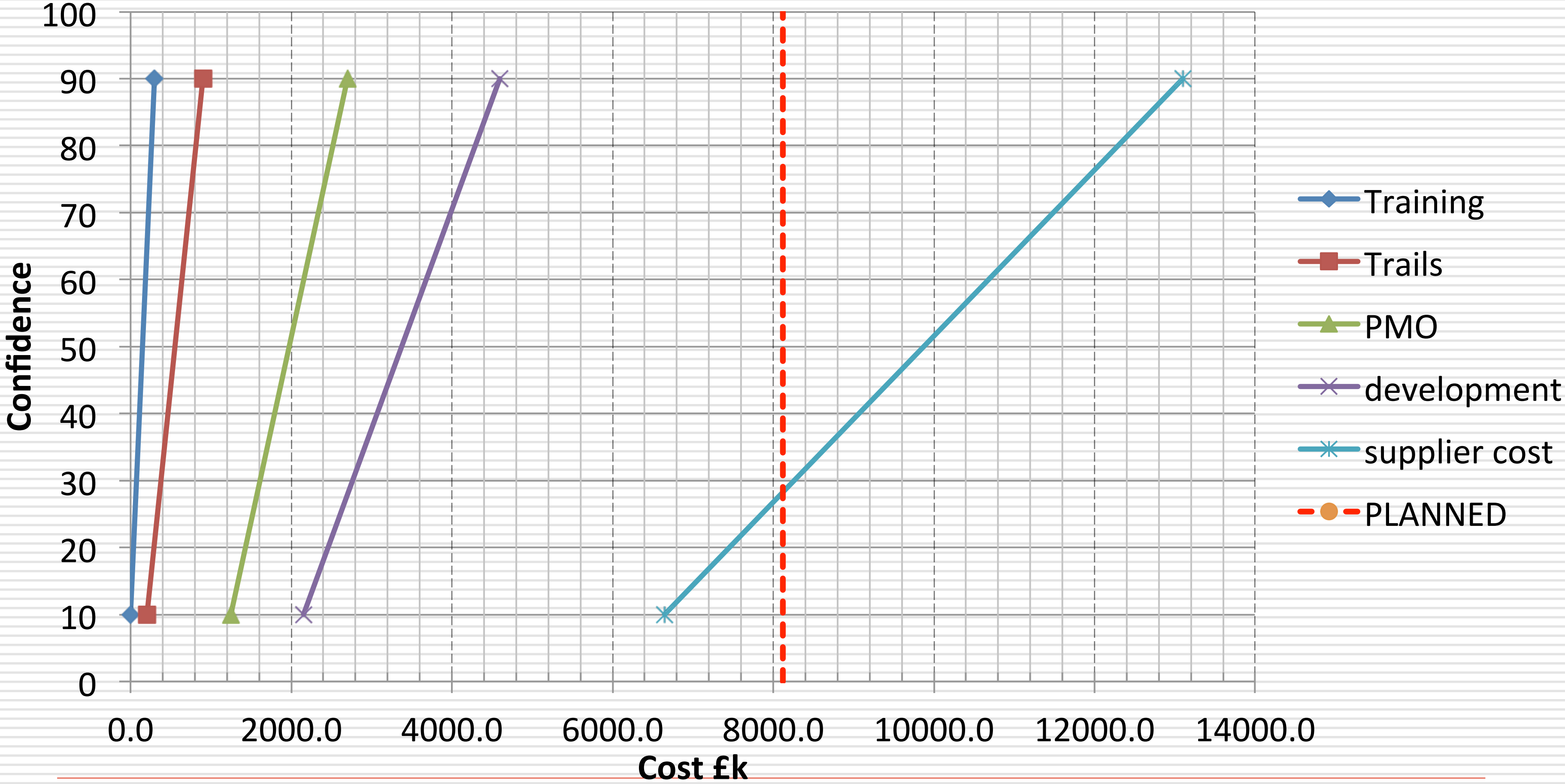
Defence supplier bidding for a prime role to design and build a fleet of vehicles for the MOD. Our main sub contractor is not yet chosen.

- Sub Contactor 1 – $7,800K (£4,800K – current exchange rate)
- Sub Contractor 2 – 7,487K Euros (£6,000K – current exchange rate)
- Other Costs
  - Development £1,400K
  - PMO Costs £1,220K
  - Trials £ 450K
  - Training £ 250K
- Deterministic baseline cost = £8.12M (Based on cheapest bidder)

# First Pass Model – additive elements

| Cost Component | Optomistic P10 (£) | Pessimistic P90 (£) | Sources of Uncertainty |
|---|---|---|---|
| Supplier cost | 4,500K | 10,500K | Exchange Rates, material prices, contract errors, design changes |
| Development | £1,050K | 1,900K | Over estimation of technical maturity, material prices, major design problems |
| PMO costs | 1,100K | 1,800K | Schedule delay |
| Trials | 200K | 600K | Firm price from sub |
| Training | 0K | 300K | Could be included under extant arrangement, number of delegates |

# First Pass Output

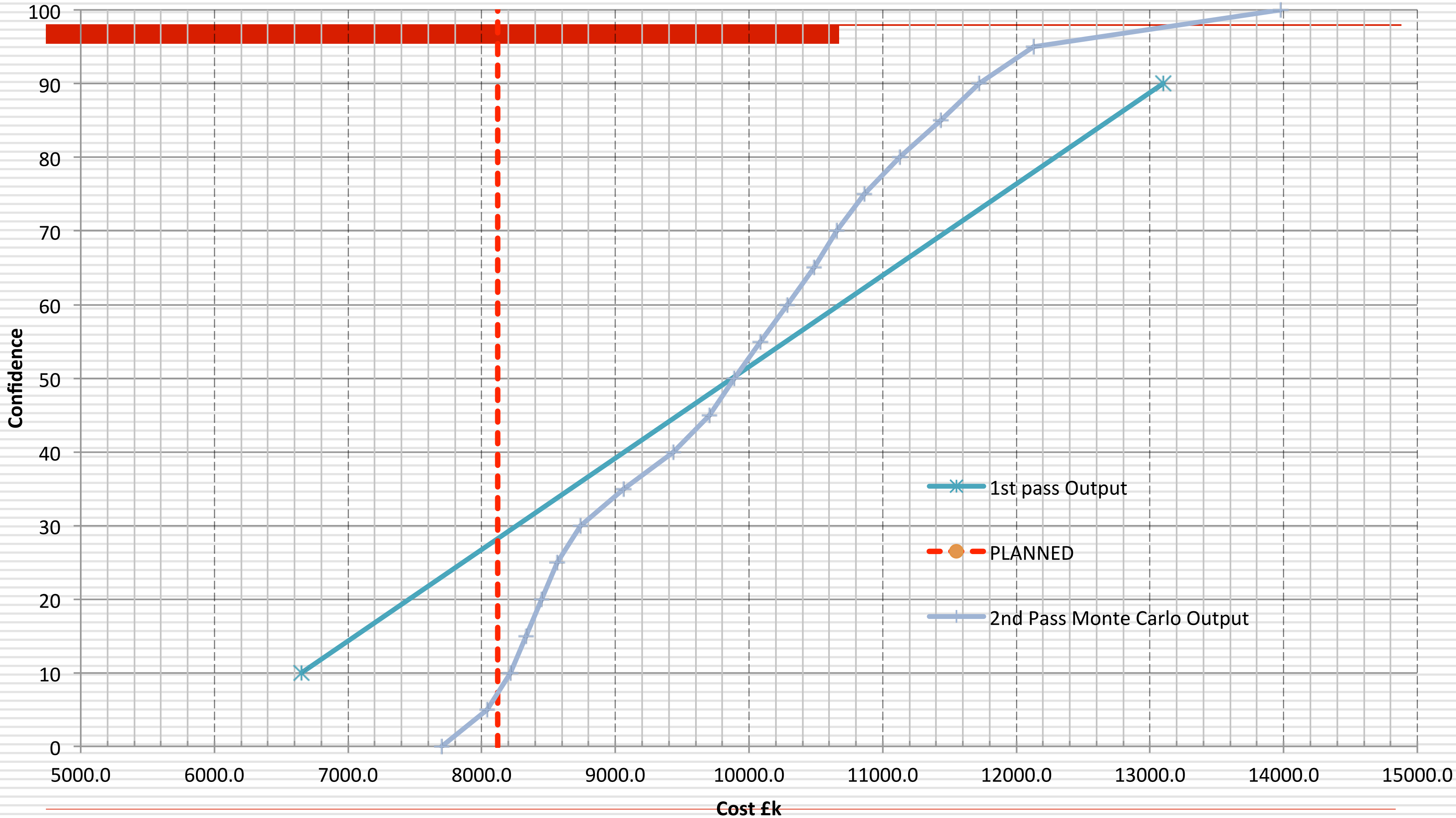


# Second Pass design considerations

- Supplier choice is critical and requires more detail
- Cost elements and risks that can be summed:
  - Supplier price
  - Risk of Scope based Contract Errors leads to financial liability
  - Risk of major design changes as a result of our redesign
- Multiplicative effects need to be modelled, i.e. cost of materials, exchange rates etc
- Mutually Exclusive situations
  - Only 1 supplier can be selected.
- Cost/Risk Element correlation (potentially exchange rates)

| Cost Element | Probability | Occurs | Min | Most Likely | Maximum | Simulation Cost (K) | Outcome (K) |
|---|---|---|---|---|---|---|---|
| Supplier A Price | 100 | 1 | 7800 | 7800 | 7800 | 7800 | 7800 |
| Scope based errors | 60 | 0 | 20 | 150 | 490 | 30 | 0 |
| Major Design Change | 20 | 1 | 100 | 1000 | 1900 | 1400 | 1400 |
| | | | | | | Supplier A Total ($) | 9200 |
| Exchange Rate | 100 | 1 | 0.55 | 0.63 | 0.71 | 0.65 | 0.65 |
| | | | | | | Supplier A Total (£) | 5980 |

# Monte Carlo v First Pass

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# 2nd Pass Monte Carlo - Observations

- Less risk than first pass (note the angle of the curve)
- Key Drivers
  - Material fluctuation
  - Exchange Rate (multiplicative effect)
- Potentially dramatic effects
  - P80 First pass = £12.3M
  - P80 Second pass = £11.2M
- 2nd pass uses a more detailed and representative model
- 3rd pass and so on.......

Better Inputs

# RISK DESCRIPTIONS

# Typical Formulaic Descriptions

**Formulaic approaches may be better than nothing, but often produce poor results**

1. There is a risk that….. this is because…. If this occurs….

2. If….. then….

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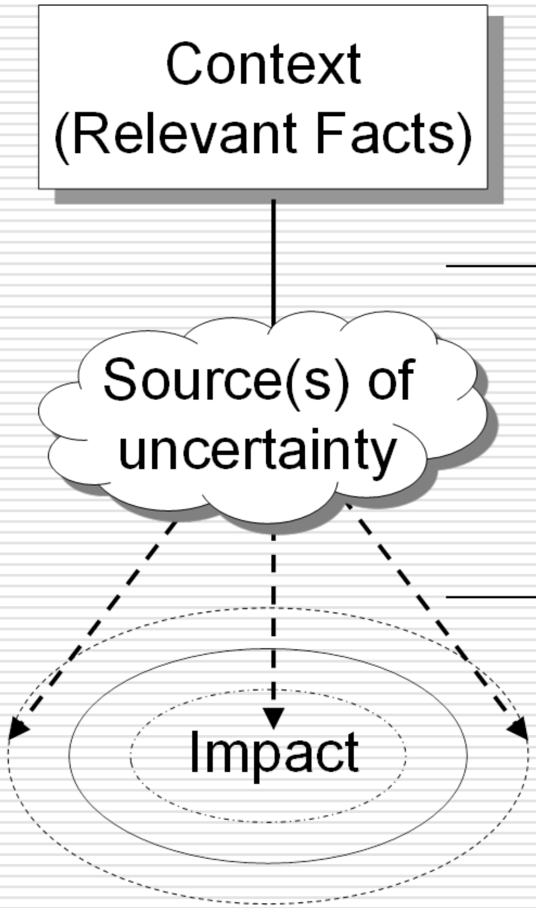
**One issue is that they tend to produce an atomised risk register:**

Risk ID 238 - If the requirement spec is delayed …

Risk ID 143 - If the tendering process takes longer …

Risk ID 115 - If the supplier delivers late …

# Recommended Structure



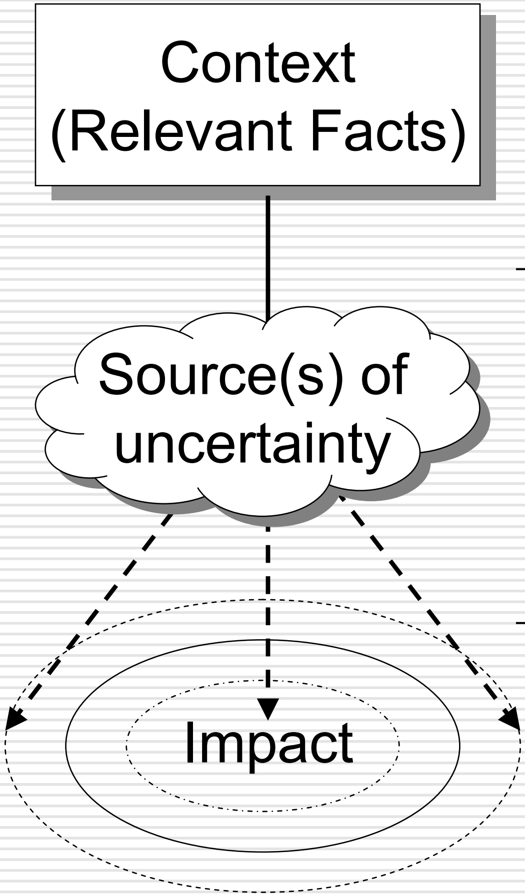

What we know (or what it is reasonable to assume that we know)

What we know we don't know

The potential consequences

REF APM PRAM AND ISO 31000

# Risk Title: Power Distribution System Late Delivery

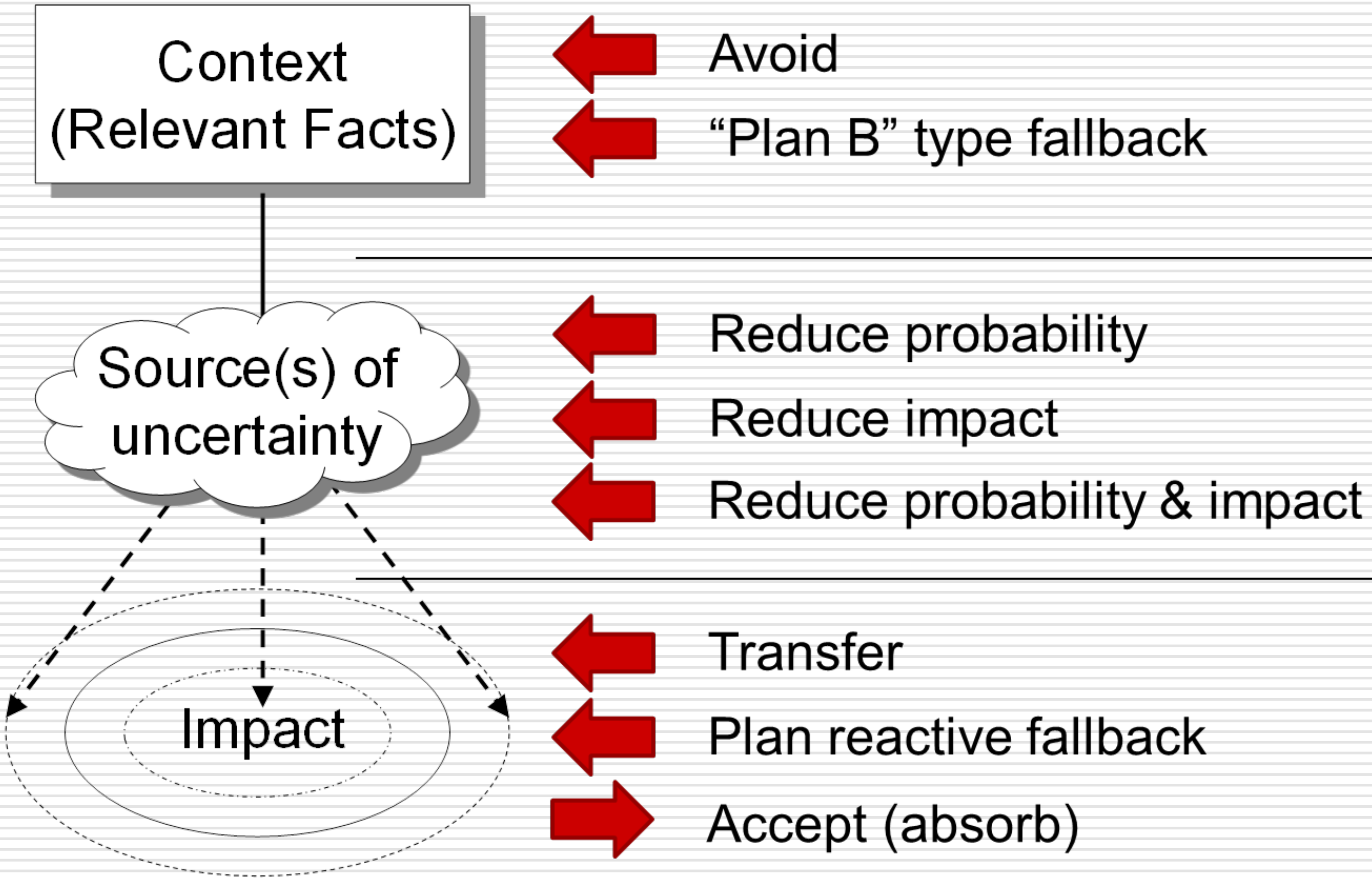



It is planned that the power distribution system will be delivered by May 2015. Procurement strategy is competitive tender.

1. May be a requirement specification delay
2. Potential for competition process delay
3. Subcontractor may not deliver to contract

Delay to the commencement of Electrical systems integration

# Risk Responses (Threats)



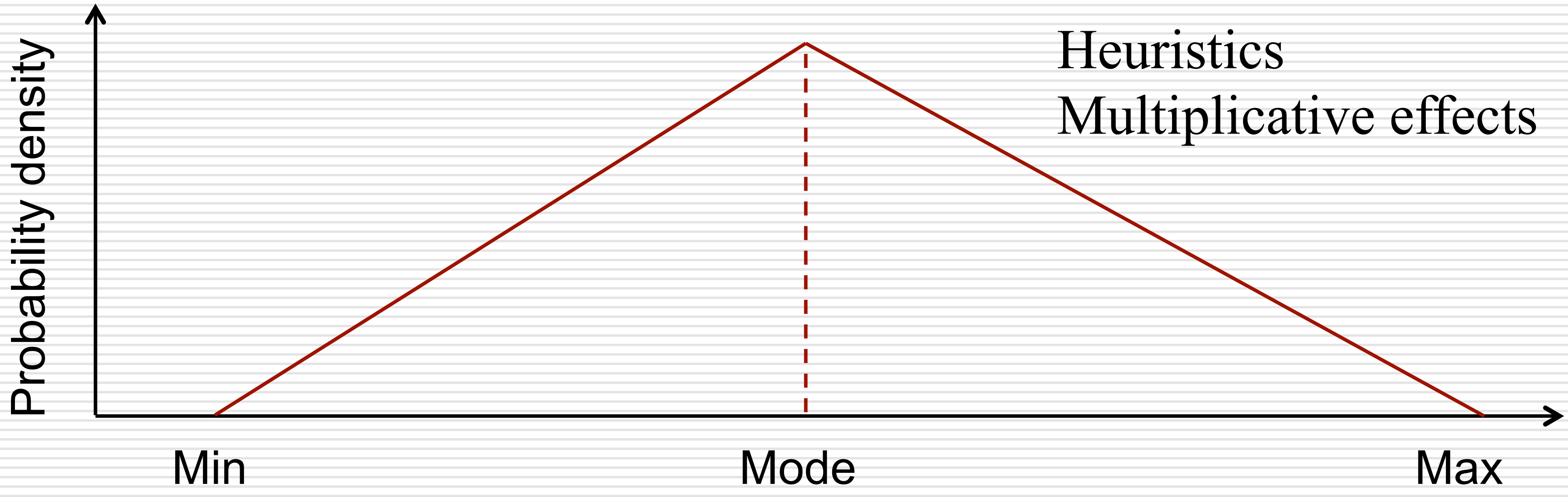

REF APM PRAM AND ISO 31000

Better Inputs

# RISK ESTIMATES

# 3 Point Estimates

3 point estimates are often too narrow



# Multiplicative Effects – often missed

- It is known that a proportion of cables in the vehicle being developed will require triple screening:
  - A baseline estimate for cabling costs has been included in the price build
    - 100 cables per vehicle = £100,000 per vehicle for all cabling
    - £10M for the fleet of 100 vehicles
- + - 10% uncertainty template
  - £9M – £11M

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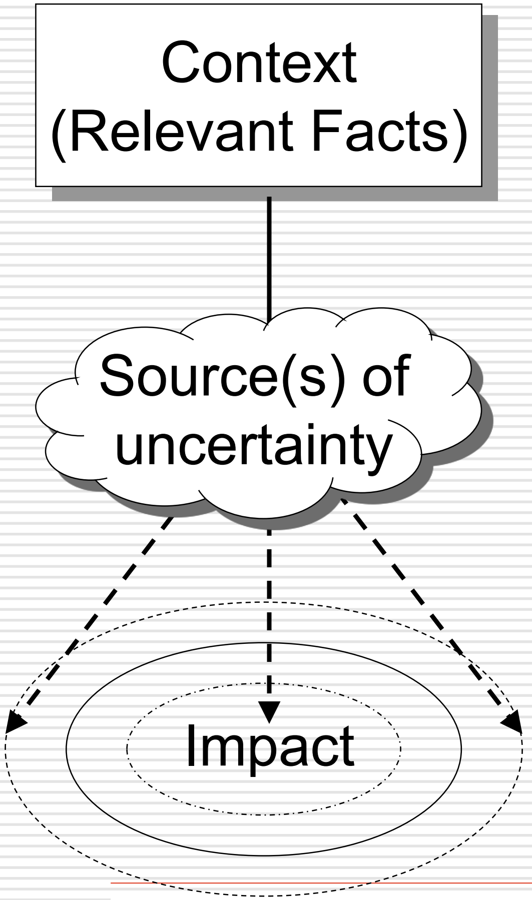
# CONTEXT AND SOURCES OF UNCERTAINTY

- Investigation into sources of uncertainty
  - Baseline assumes 100 cables per vehicle, where as it could be between 80 and 150
  - Up to 100% of cables might need screening, +£500 per cable
  - Average unit costs historically vary from £700 – £1300 for cables
- WORST CASE ESTIMATE COULD BE
  - £270,000 per vehicle
- BEST CASE COULD BE
  - £56,000 per vehicle
- FLEET COST
  - £5.6M and £27M

# Improved Three-Point Estimates

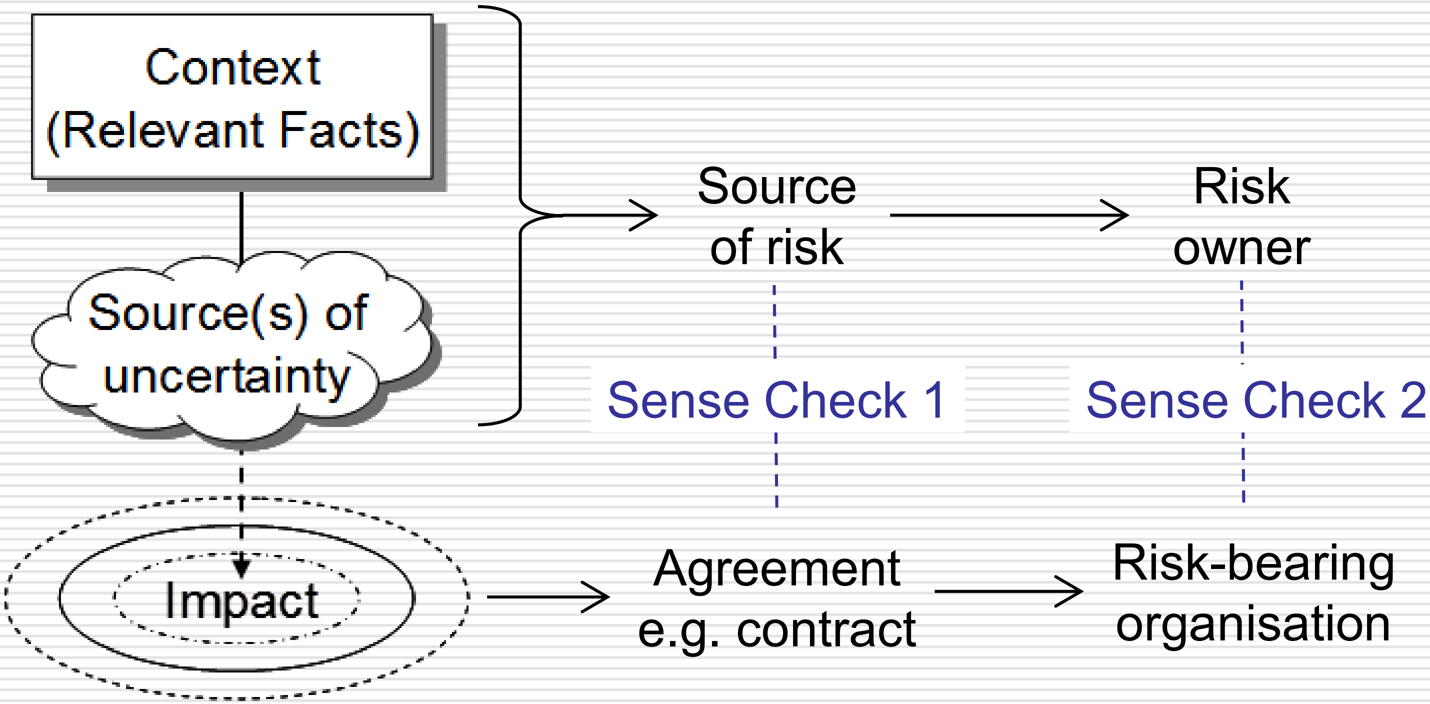



1. Develop a sound description of the risk involved, identifying all significant sources of uncertainty
2. Clarify with the estimator the implications of using extreme points or confidence points
3. Make the Worst case estimate, based on how sources of uncertainty could combine
4. Make the Best case estimate, combining optimistic estimates for each factor
5. Make a realistic Most Likely (Mode) estimate based on a balanced judgement
6. Resolve or accept any difference between the Mode estimate and the planned value
7. **Document the basis for estimates**

Better Inputs

# RISK OWNERSHIP

# Risk Ownership – Two very separate roles




It is recommended that two aspects of risk ownership are considered:

**Risk owner:** the person who has the most influence over the risk's outcome

**Risk-bearing organisation**: the party that bears the risk's cost implications

REF APM PRAM AND ISO 31000

# Key Learning Points

- Use an iterative and top down approach to risk model development
- Capture justification for model design and inputs
- Take care to capture how cost components are likely to behave in relation to one another and capture that behaviour in the model
- Three Point estimates are best developed by identifying the sources of uncertainty that may combine/multiply together to drive optimistic and pessimistic estimates
- It takes time to get this right. Plan for it!

# QUESTIONS?