Project Portfolio Analysis Under Uncertainty

Presentation to ISMOR 34

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Content

- The problem: Obtaining Value-for-Money (VFM) from portfolios of technology projects
- Approach: How existing methods were combined
- Model implementation
- Challenges, opportunities and conclusions

The Problem

- To identify/select portfolios of technology projects to support *potential* future major acquisition programmes
  - Conditions of substantial uncertainty regarding the future
  - Positioning to keep options open
- Obtaining Value-For-Money from the investment
- For UK, the process adopted needs to be auditable and suitable for supporting an MOD business case
  - Being transparent about the uncertainty

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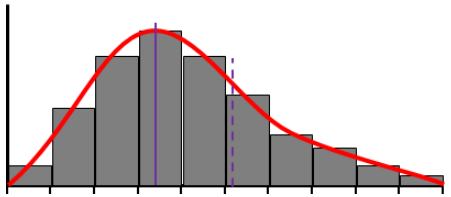
Integrated Approach - Introduction

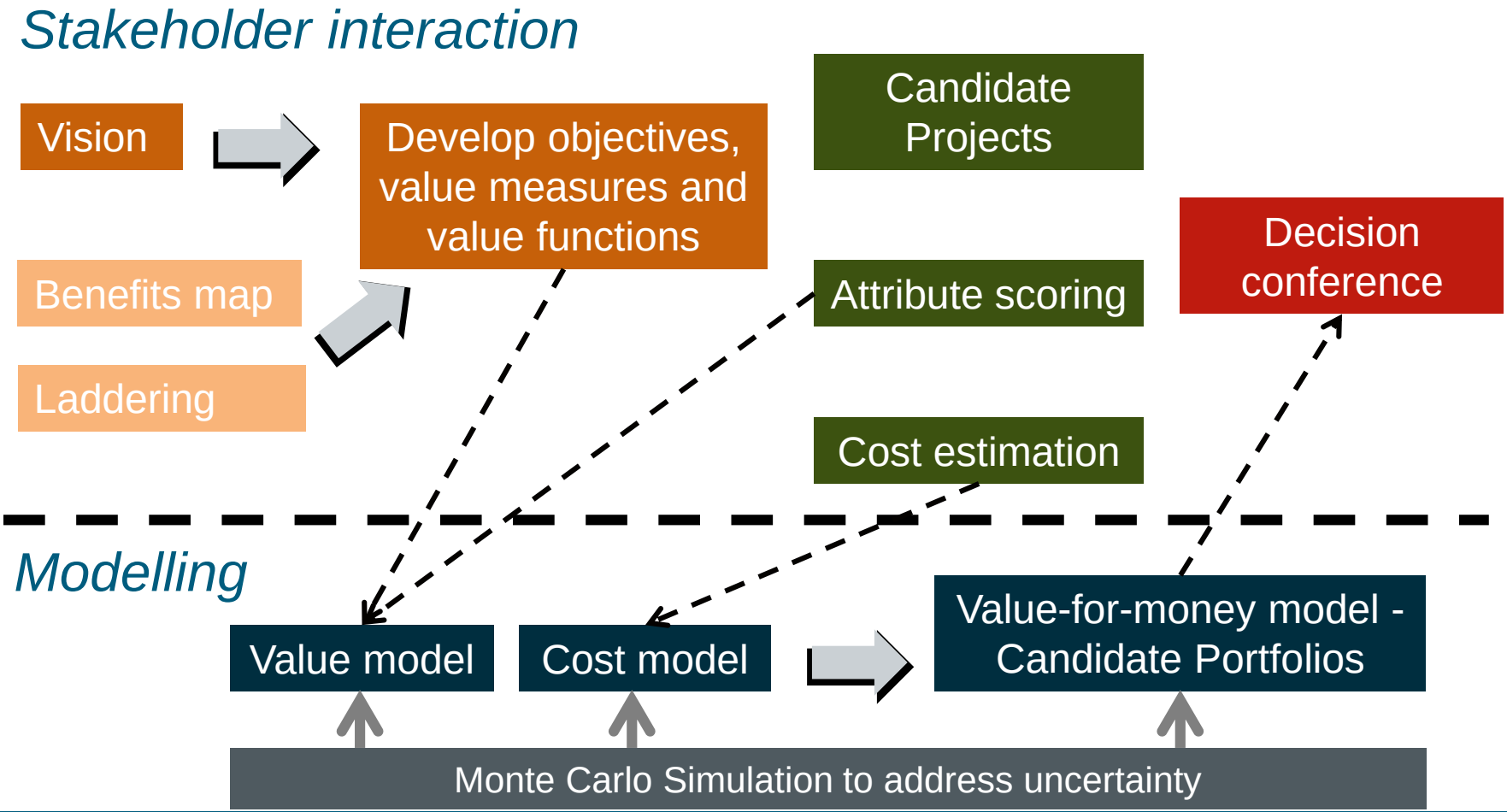
- Two MCDA methods provided the Core Approach:
  - The 'Front end': *MCDA underpinned by Value Modelling* [Ref. 1]
  - The "Back end": *MCDA , portfolio VFM analysis and Decision Conferencing* [Ref. 2]
- These approaches were readily combined as they neatly overlap
  - Where MCDA produces a single non-monetary estimate of Value (or Benefit)
- Other non-quantitative methods were use to support initial problem exploration at the "front end":
  - Benefits Mapping [Refs 3,4]
  - Laddering
- **Innovatively, *Risk Analysis* methods were integrated into the entire approach to investigate uncertainty in value and cost**

Focus on uncertainty



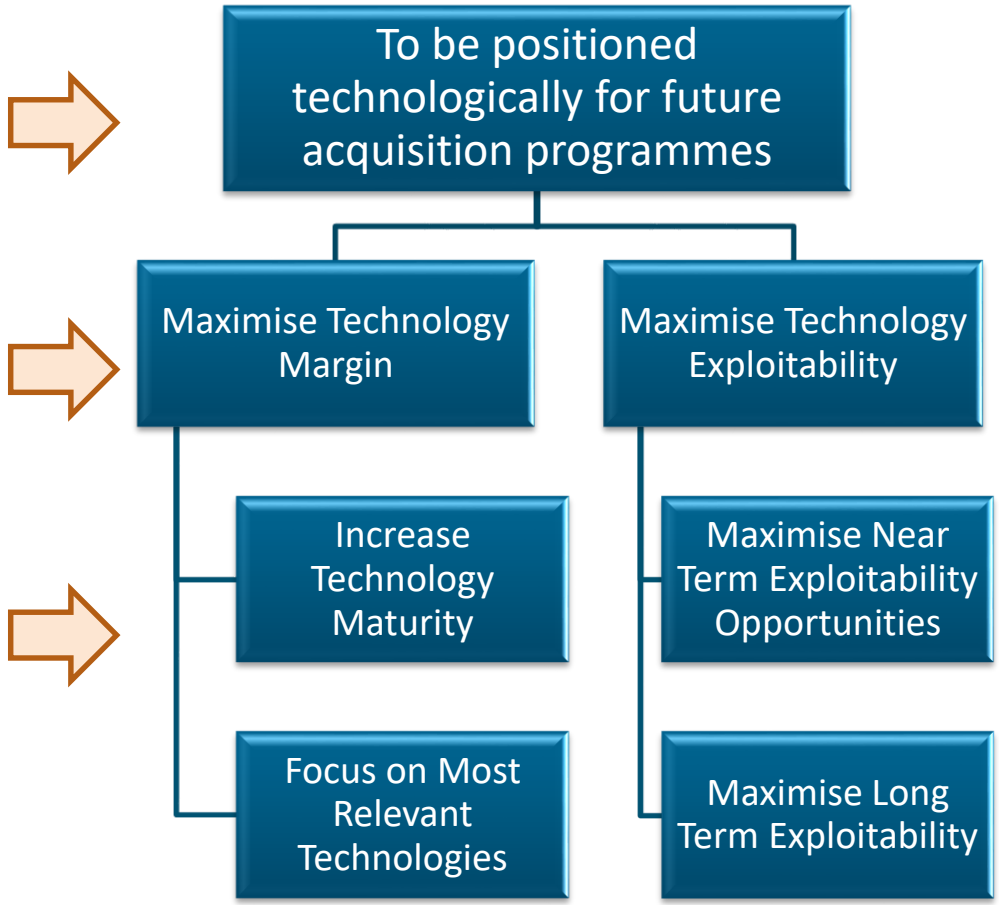
- Would it be possible to extend the Core Approach to give a more comprehensive treatment of uncertainty?
- To go beyond using single point estimates of value and use of fixed risk-adjustment factors to one that truly embraces uncertainty
- Using methods currently practiced in cost & schedule risk analysis
  - Such as the process used within MOD's own cost-estimation service (CAAS) for generating 10/50/90% cost estimates for business cases
- That is, representing uncertainty in benefit or cost with probability distributions or samples and using Monte Carlo simulation to calculate derived measures
  - Including measures of VFM

The Complete Approach



The Objectives and Value Tree

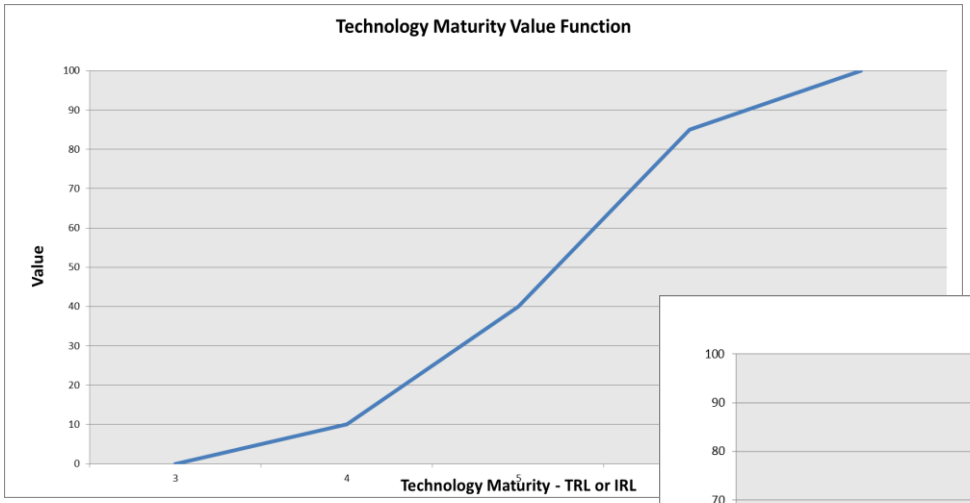
- Vision
- 2 High-Level Objectives
- 4 sub-objectives / value measures
  - These would allow discrimination in value between individual technologies



Value Functions

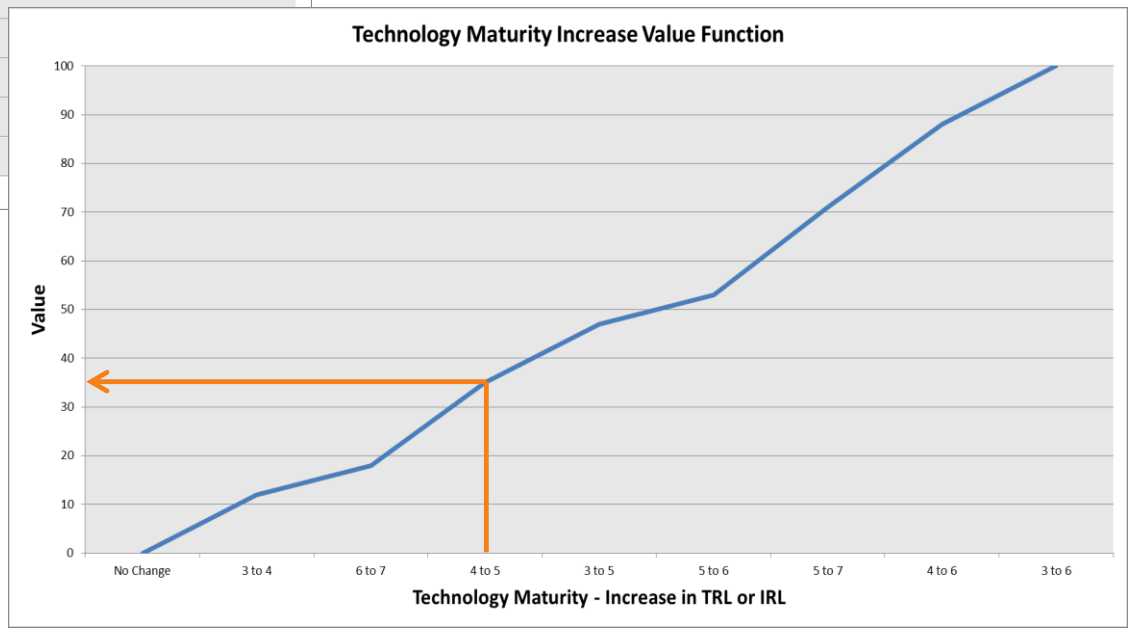
- For each of the 4 value measures, value judgements were elicited from stakeholders to create corresponding value functions
- Two are described:
  - Technical Maturity
  - Long Term Exploitability (LTE)

Technical Maturity Value Function



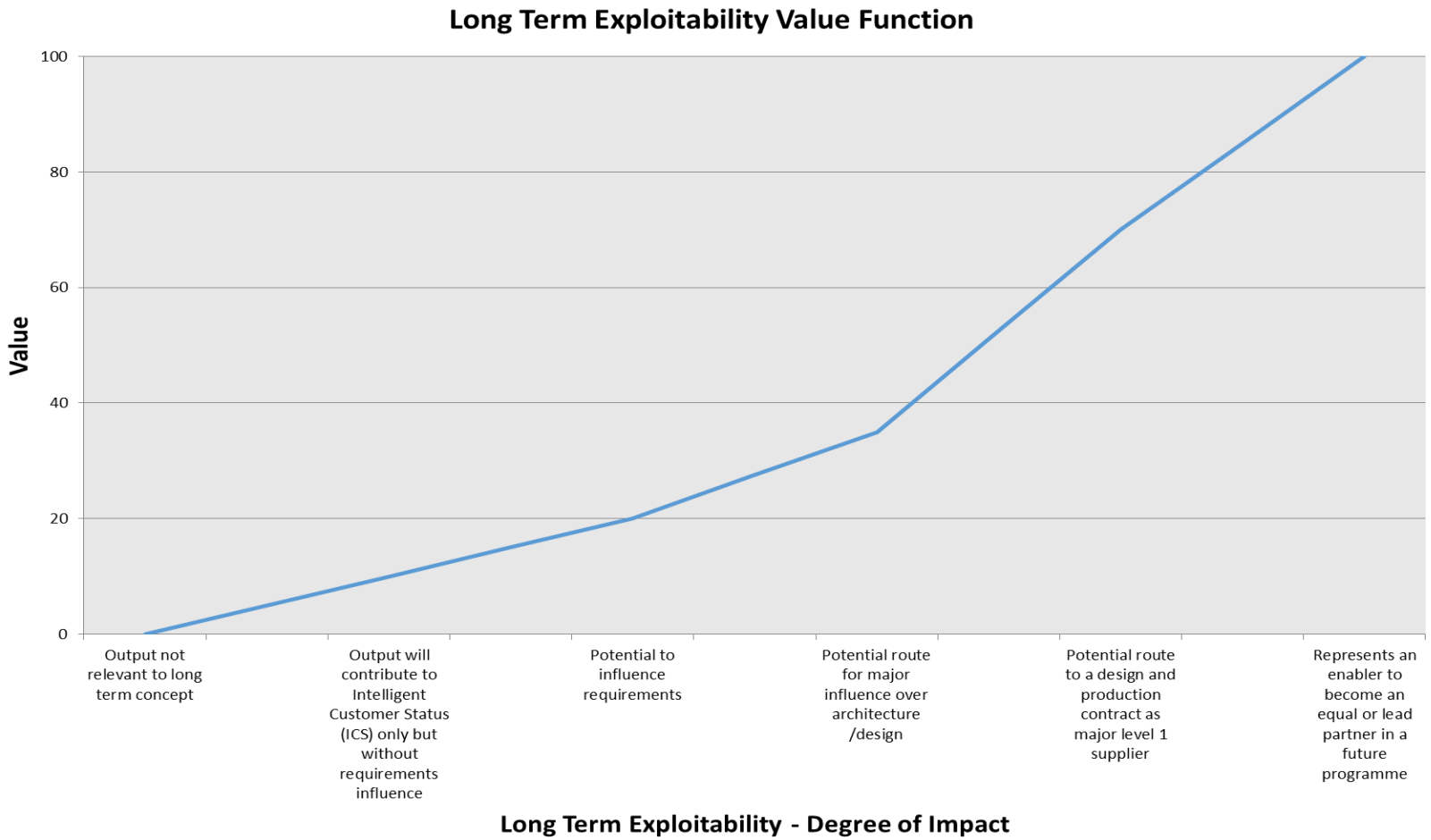
Initially stakeholders considered the relative value of achieving different technology maturity levels

This was used to derive the value of *increases* in maturity which stakeholders agreed better represented value



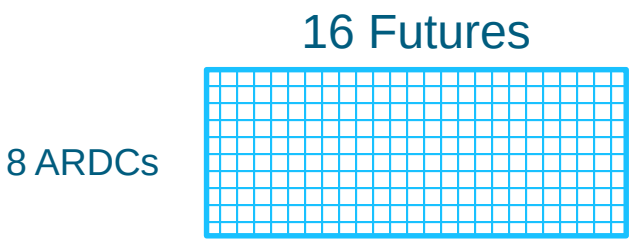
TRL = Technology Readiness Level
IRL = Integration Readiness Level

Long Term Exploitation Value Function



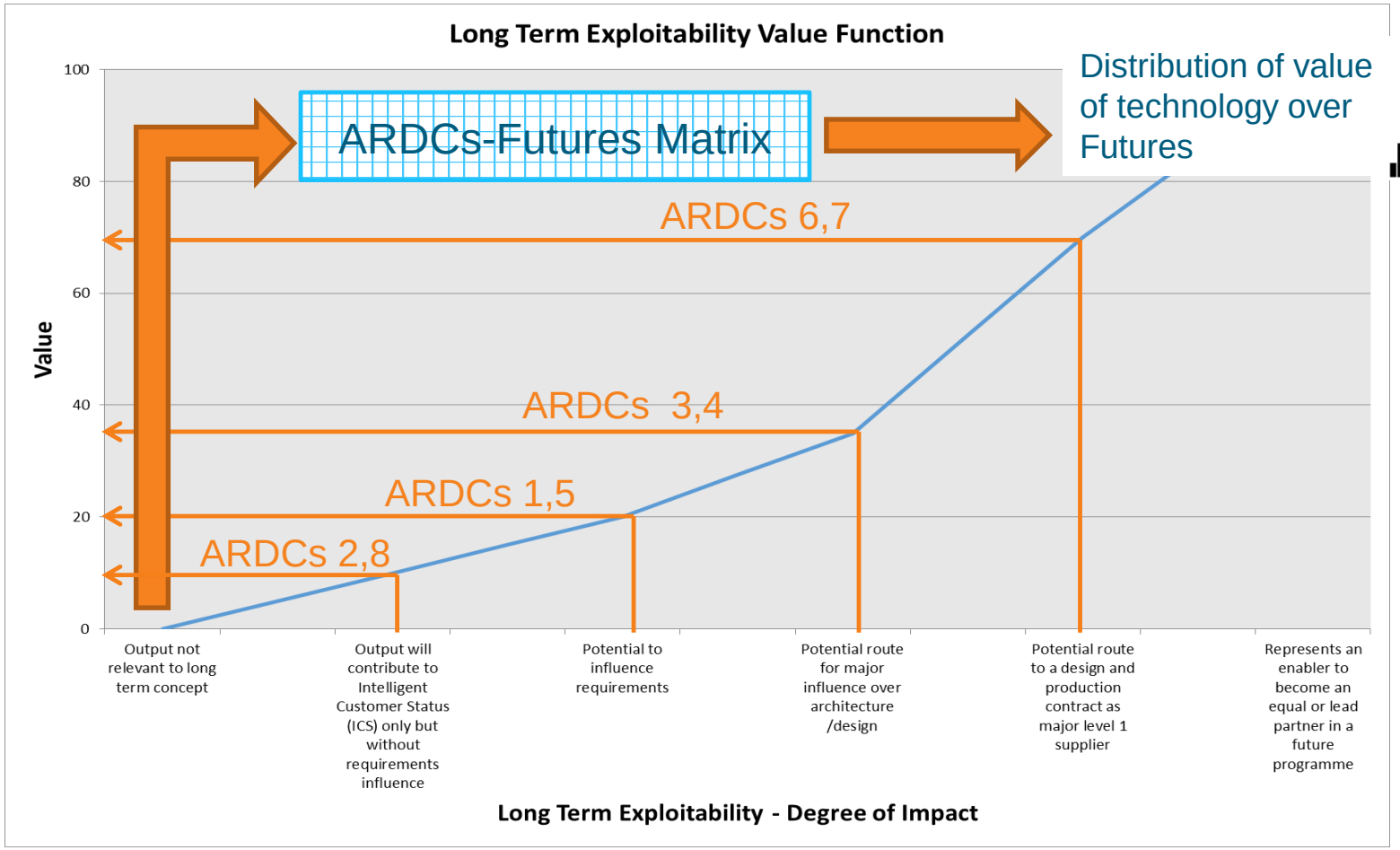
Futures and future concepts

- Stakeholder discussion agreed on a set of 16 representative Futures
- Each was defined by a different mix of 8 potential Acquisition Route Dependent Concepts (ARDC)
  - ARDC = a conceptual system + an assumed acquisition route



ARDCs-Futures Matrix

Applying ARDCs to the LTE Value curve



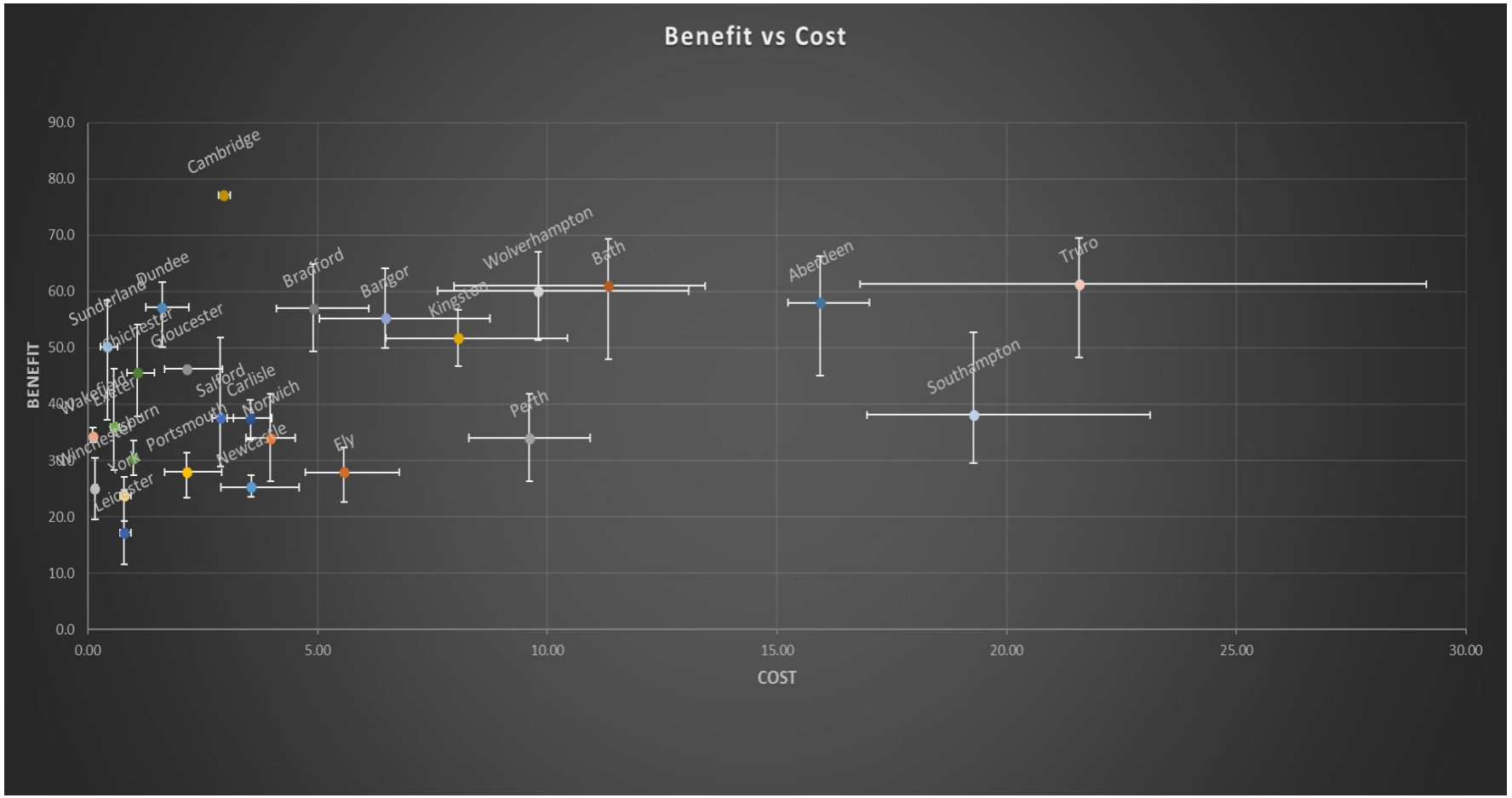
Combining the Value estimates

- The value measures represent the MCDA decision criteria
- They are weight-summed
  - Swing weighting was used to estimate the weights
- However, given that one of the individual values, LTE, is stochastic, this weighted-summing was done within the Monte Carlo Simulation
- The resulting total value of each technology is therefore also stochastic
  - but with an absolute maximum of 100 units of value

Cost Estimation

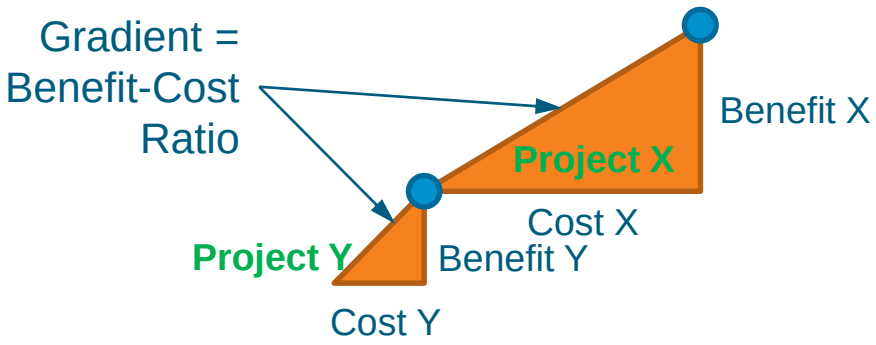
- CAAS within MOD undertook cost estimation, using their pre-existing uncertainty/risk management approach and tool
- Total project costs are represented stochastically
- The 10/50/90 percentiles are usually the only output used by MOD
- For this work, the complete distribution (All 100 percentiles) was exported to the VFM analysis

Value vs Cost scatter chart



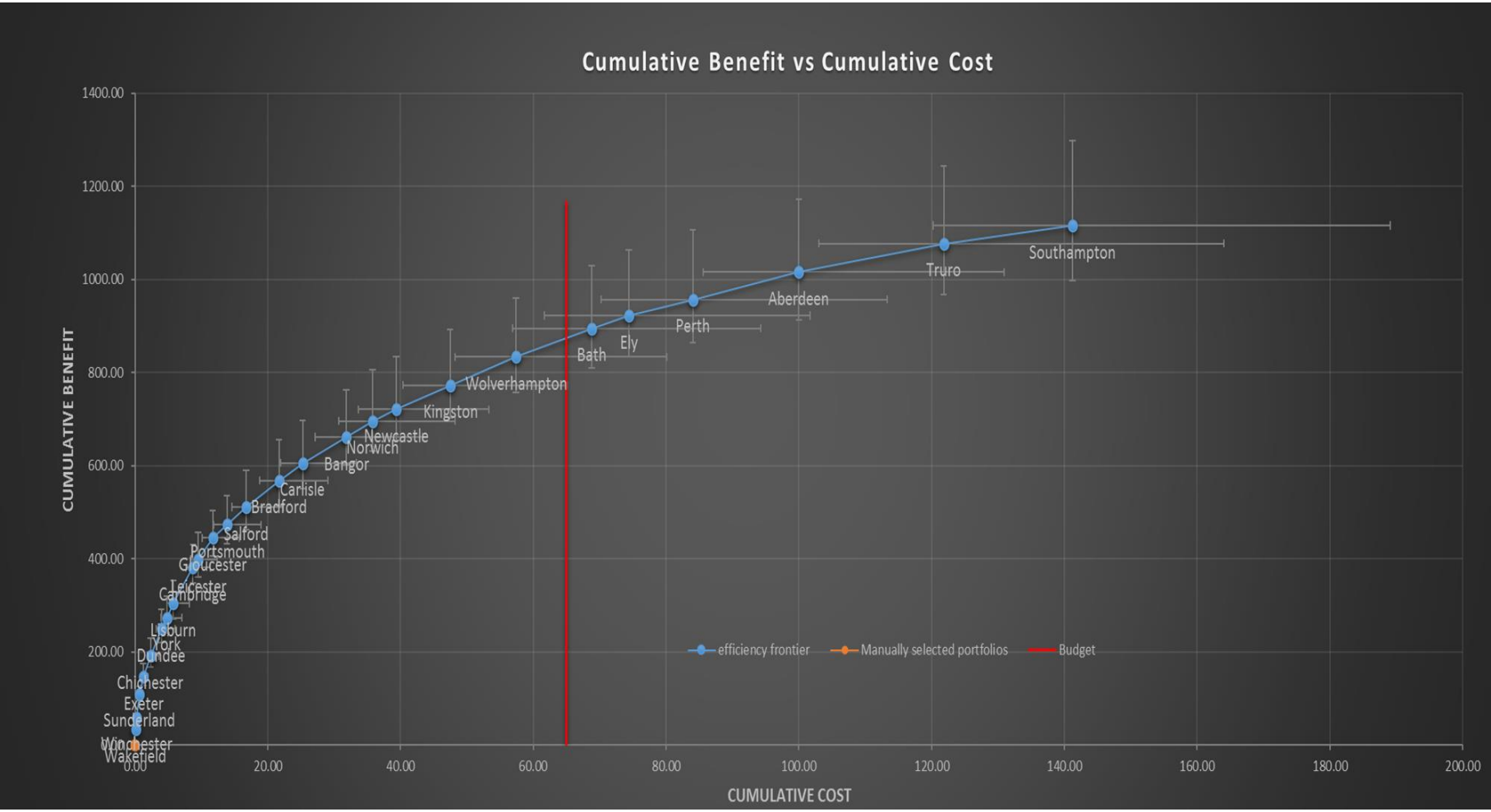
Portfolio Value-For-Money Analysis

- When benefits are expressed in non-monetary units, Benefit-to-Cost Ratio (BCR) can be used as a measure of the VFM for projects in a potential portfolio [Ref. 2]
- Projects are ranked in order of decreasing BCR

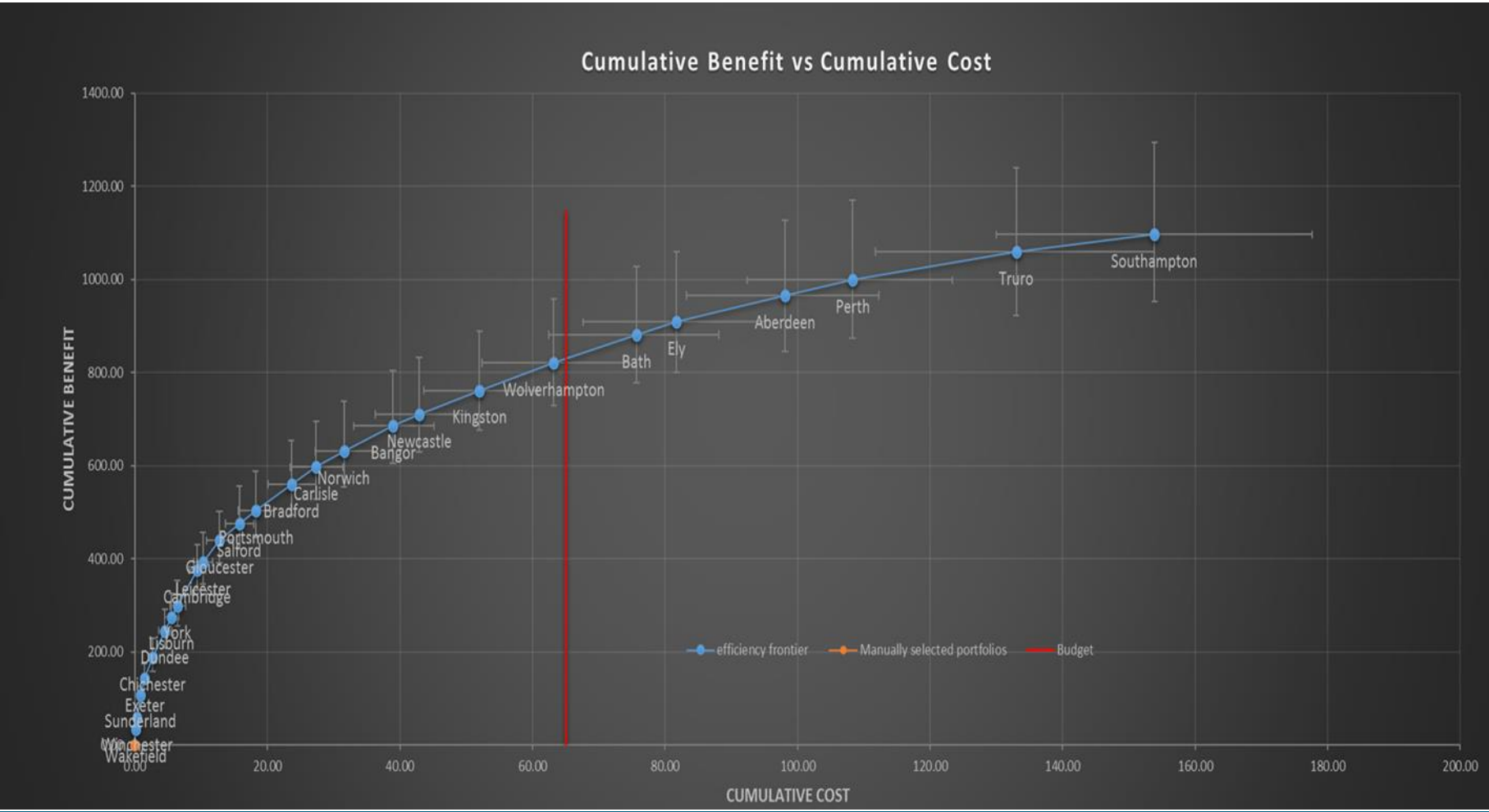


- Under uncertainty, projects are ranked by *true median BCR* then plotted by *true median cumulative benefit* vs *true median cumulative cost*

Pareto frontier

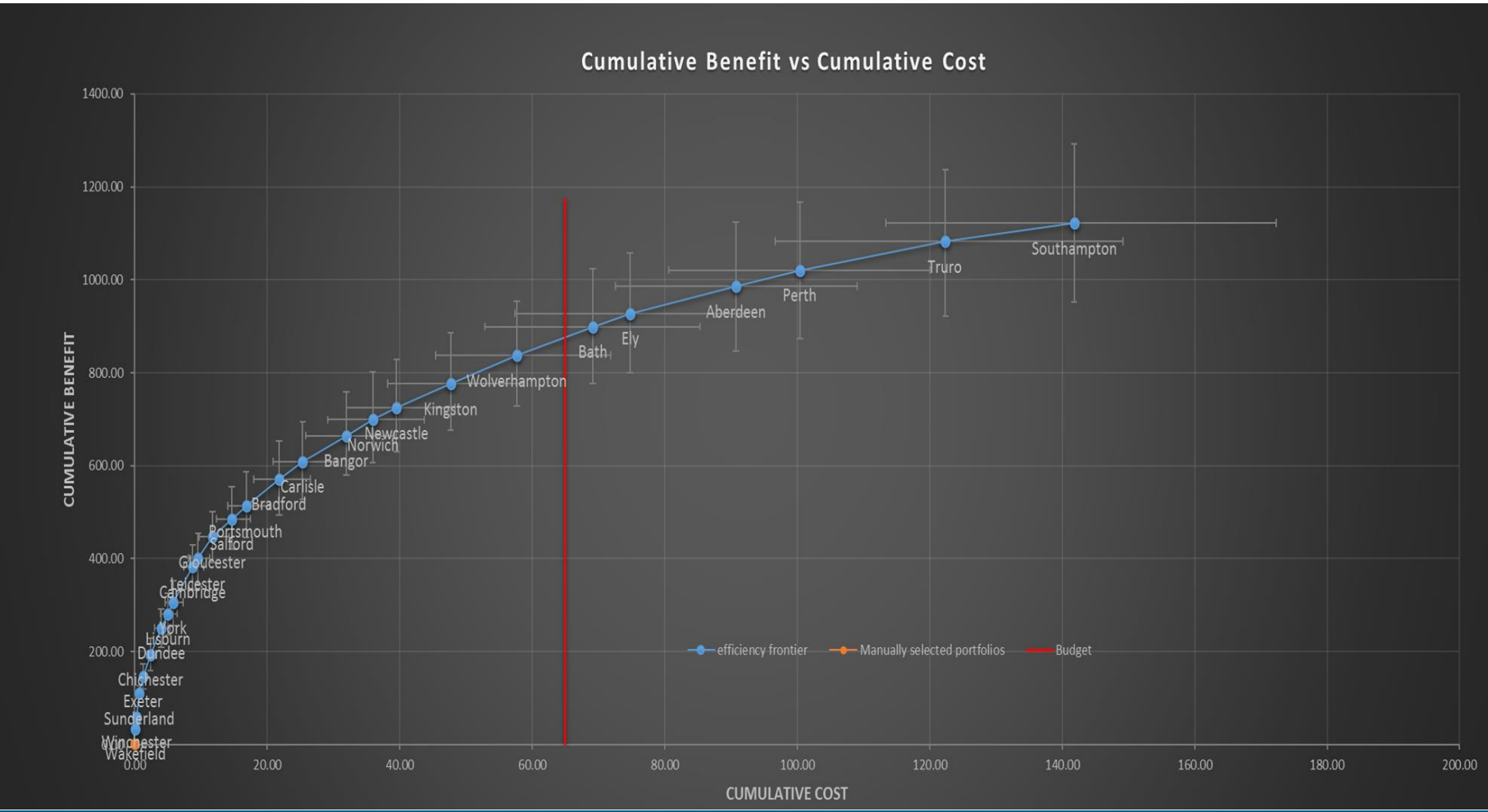


Pareto frontier (second simulation)



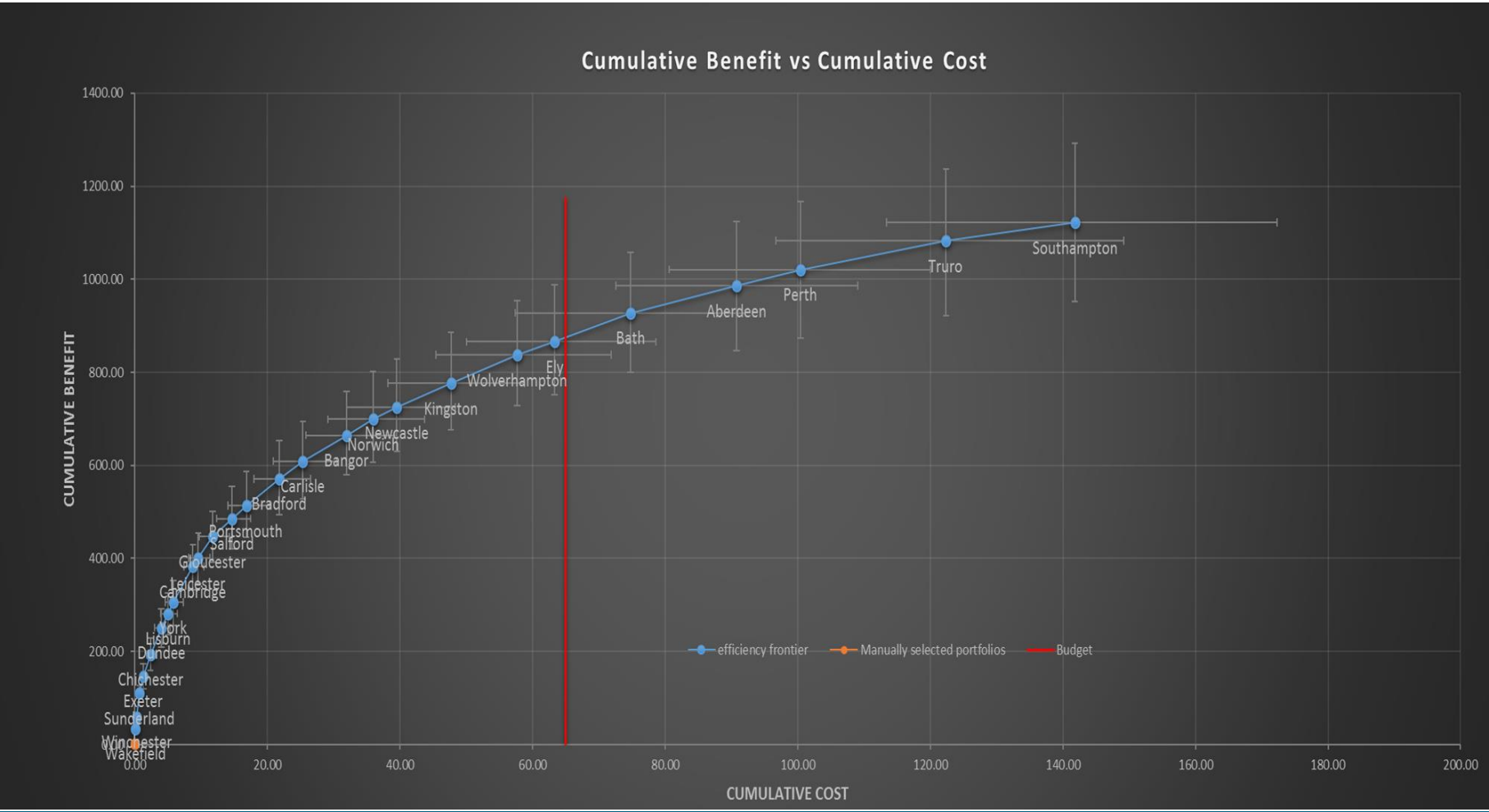
Ministry of Defence

Pareto frontier (third simulation, increased no. trials)



Optimisation of the Frontier

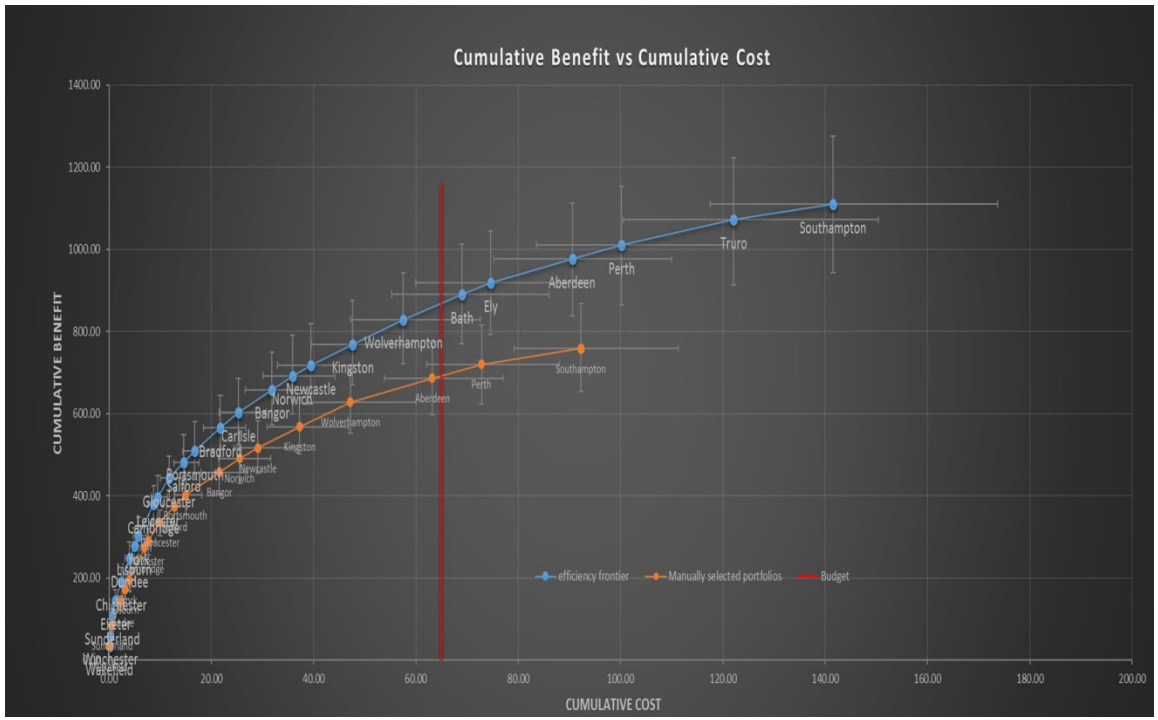
Ref. 5



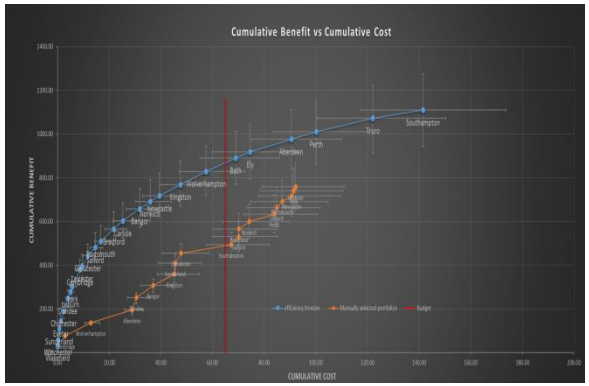
Ministry of Defence

Comparative Portfolios

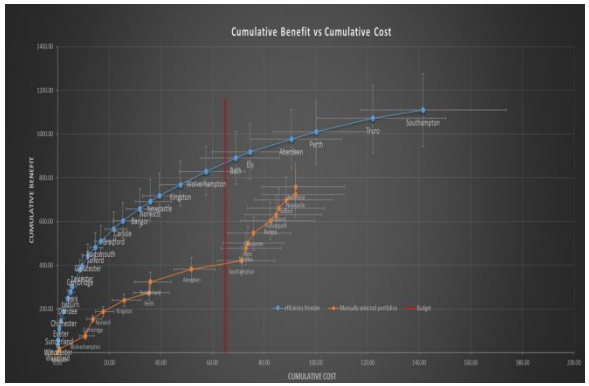
Sub-sets of projects provide alternative portfolios for comparison in the Decision Conference



Ranked by BCR



Ranked by Value

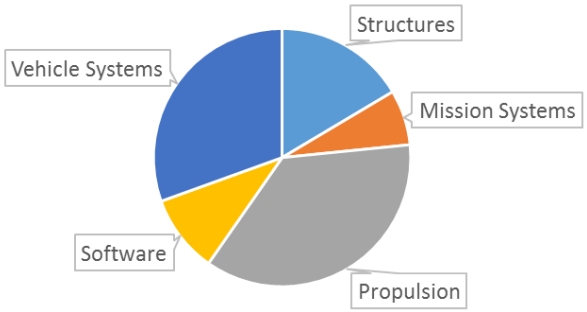


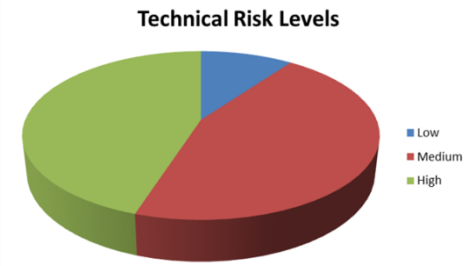
Ranked by manual priority

Portfolio Dashboards

Allows the Decision Conference to assess candidate portfolios …

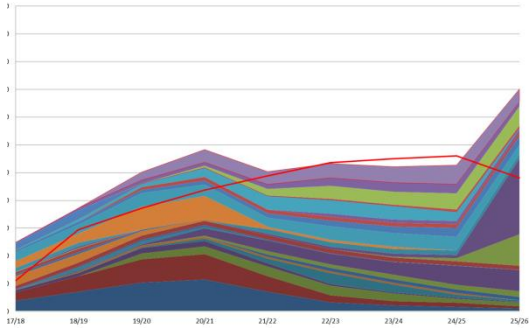
… for balance (in different forms)





… for inter-dependencies

.. and for annual affordability



Model Implementation

- Main requirements for model implementation were:
  - Engaging visualisations and sufficient responsiveness to allow interactive analysis with stakeholders
  - Usability & maintainability
  - Ability to use affordably across MOD
- The model was implemented in Excel 2016 using a freeware Add-in for the Monte Carlo simulation
  - 'SIPmath™ Modeller Tools' from probabilitymanagement.org

Challenges and opportunities

Challenges

- Dynamic range of value scale compared to cost scale
- Independence of value measures (decision criteria)
- Project inter-dependence
- Correlation of benefit uncertainty

Opportunities

- Optimisation within the Monte Carlo simulation
- Optimising on other parameters e.g. lowest Regret
- Technology opportunities (software and hardware)

Conclusions

- Uncertainty analysis has been successfully integrated into a MCDA based Value for Money analysis supporting a technology portfolio
- It is being applied to support decision making for a major UK technology investment programme
- The approach and implementation approach has potential for further development and broader application