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Ministry of Defence

Ex-ante Research Portfolio Valuation using Uni-criterion Analysis Methods

Presentation to ISMOR 33

Gordon Pattison, Dstl Fellow

agpattison@dstl.gov.uk

What is the overall value of the research programme?

You mean to tell me that you can't prove that the research portfolio delivers the highest value of all the possible portfolios !?


Predicting
the
Future

Valuing S&T research

- Academic best practice (Science Policy Research Unit, University of Sussex) says to use:
  - Case studies (retrospective)
  - Surveys (qualitative)
  - Econometrics (quantitative)
- Only the last of these has the potential to provide an overall or portfolio valuation, particularly *ex ante*
- But it is the only one we don't do currently

Econometrics

- To maximise the value of the portfolio, you need to
  - Have an agreed measure of value
  - Have a method to attribute value to specific proposals
  - To monitor the growth or decline in value over time
  - To be able to sum the value of multiple proposals
  - To be able to understand the value of interconnected proposals
  - To use the value to make initial and downstream decisions (e.g. to switch between options)

MOD's current valuation method

$$NPV = C_0 + \sum_{t,i=1}^{N-1} \frac{C_i}{(1+r)^t} > 0$$

C_0 = initial investment

r = discount rate

t = time related to a specific point in project lifecycle

C_i = cash flow over life of project, where C_i = ($revenues_i$ – $expenses_i$ – $investments_i$)

N = total number of cash flows

Method 1

Value expressed in monetary terms

Real Options Analysis in discrete time

Preliminaries

- Monetary valuation is powerful and would allow immediate access to finance/economic methods
- ROA widely used in companies for R&D decisions over 20 years, following 20 years of method development
- Permitted by MOD in JSP 507*
- Transparent model a requirement of this work

* But never used (so far)

When to use an options approach

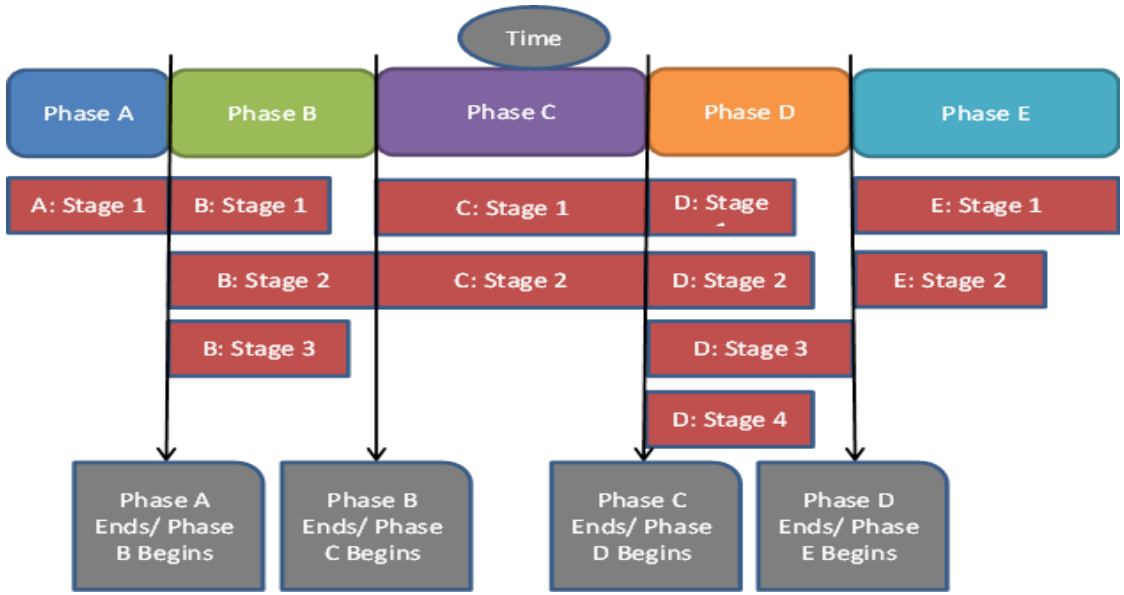
- From Amram & Kulatilaka (1998)
  - When there is a contingent investment decision
  - When uncertainty is large enough that it is sensible to wait for more information
  - When the value seems to be captured in possibilities for future growth options rather than current cash flow
  - When uncertainty is large enough to make flexibility a consideration
  - When there will be project updates and mid-course strategy correction

What is the underlying asset value?

- No economic meaning for the value of defence output
- A proxy measure is the amount of money that defence spends to acquire/improve capability
  - The Through-Life Cost represents how much MOD is willing to pay; it is a Boundary Value (BV)
  - Future costs of capability are uncertain or *volatile*
  - CAAS 'Should cost' model can provide 3PE of 'asset value'
- With asset value, volatility, cost of R&D, time and P(success), a model can be parameterised

Modelling approach

- Re-used Foresight Real Options Model (2004)
- Added Monte Carlo front end, built in MS Excel



Example results

	10%	50%	90%
Time for Start-up, R&D & assessment (years)	10.00	10.83	11.50
Cost of Start-up, R&D & assessment	£3,688,789	£3,958,821	£4,215,980
Underlying Asset Value	£10,813,734	£11,642,864	£12,572,587
Real Option Value	£8,005,770	£7,996,835	£7,989,198
Typical Present Value Calc.	£5,213,966.70	£4,815,261.71	£4,476,356.43

Discussion

- Portfolio value used correlation matrix approach
- There will be superior proxy measures than BV
- Risk-free interest rate is a key parameter
- How to deal with research which leads to financial benefits, e.g. spin-out
- How to ensure logical military capability portfolios
- Real Options likely to be the method of choice for S&T portfolios (Linquiti, 2015); how can defence join in?

Method 2

Value expressed in capability terms

Stochastic optimization

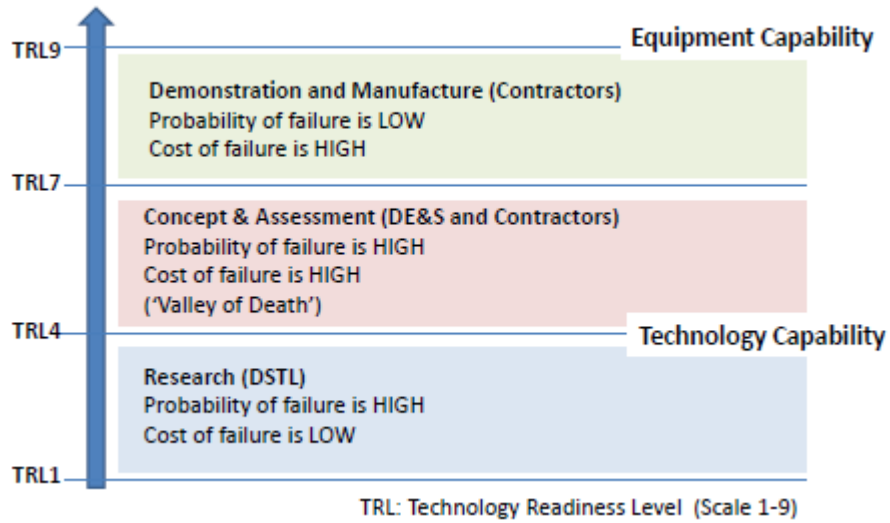
Preliminaries

- Military capability assessed by what it enables you to do
- Policy scenarios describe what we are required to do
- The most (capability) value derives from achieving the greatest number of scenarios*
- The most (research) value is that which leads to most capability value

* Likely to be concurrency assumptions

R&D growth model

- As with previous method, assume R&D is done in phases with probability to successfully complete 9 stages by the required time



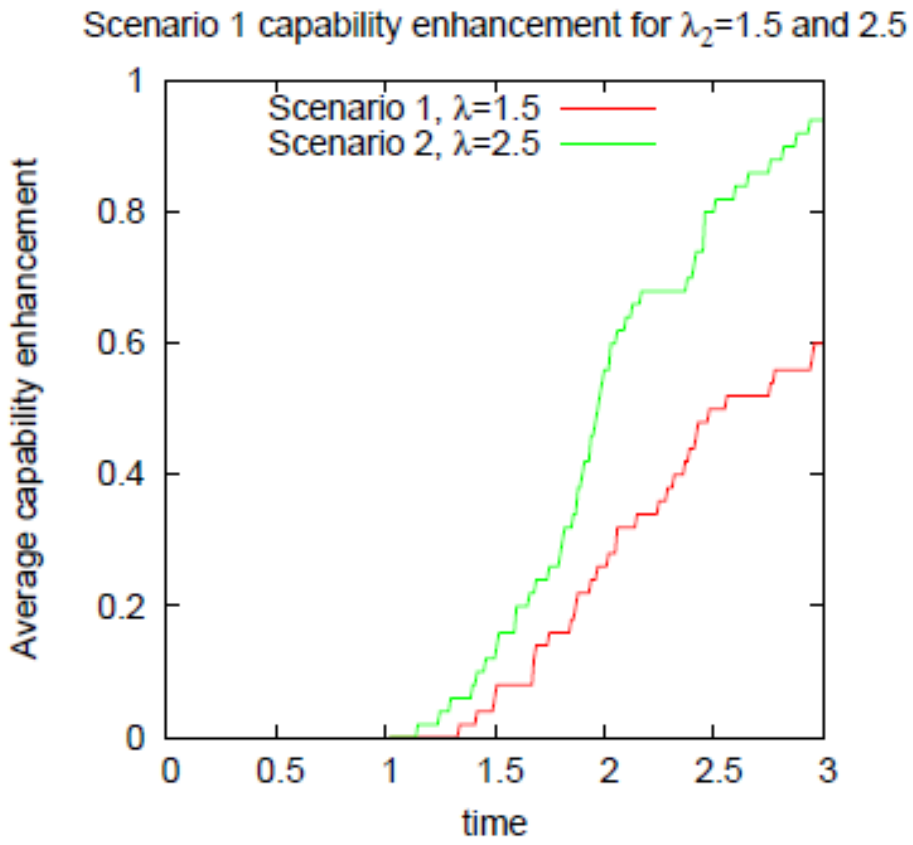
Relationship between research and capability

- Scenario success requires all necessary capabilities to be present at time T
- Research projects have probabilities that they will finish and be deployed at time T; or at a later time (unless accelerated); or that they fail; the probabilities are independent in each phase and between capability areas
- Rate of progress can be accelerated by the resources applied during research

Modelling approach

- Poisson jump processes to complete first stage of research at time intervals described by independent random variables Exp(λ1)
- Progress rate proportional to research expenditure
- Gamma distribution (3, λ1) for the time to complete first phase of research (3 stages i.e. TRL 1-3)
- Independent stochastic models for each phase (special consideration for the Valley of Death)

Initial results



Discussion

- A basic but extensible model has been developed which has already produced valuable insights
- MOD currently uses an optimization process to establish force structure based on the lowest budget to achieve the greatest number of tasks
- Combinatorial complexity with relationship between technology and equipment; and between equipment and capability, when allowing for substitutions

Acknowledgements - method 1

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Closing thoughts

- How important is it to provide a portfolio value?
- If it is, a commensurable scale will be necessary – money or capability seem the most likely units
- Two experimental methods have been developed
- Strong reliance on Information Management, especially costs, duration and probability of success
- Such methods could provide an *alternative* view to MCDA portfolio ranking approaches

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