The Use of Linear Programming in Military Operational Analysis (1968-2008)

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Logistic Modelling (1968-9)

- Assess whether the logistic transport in support of 1BR Corps was sufficient to sustain combat elements in general war on the NATO central front.

- LP benefits:
  - the model could be formulated in a few days and fed into a standard package.
  - the model would be capable of exploring the whole solution space and delivering a consistently good result over a wide range of variations.

Simplified 1(BR) Resupply System

R4

R2

R1

R5

R3

R6

R7
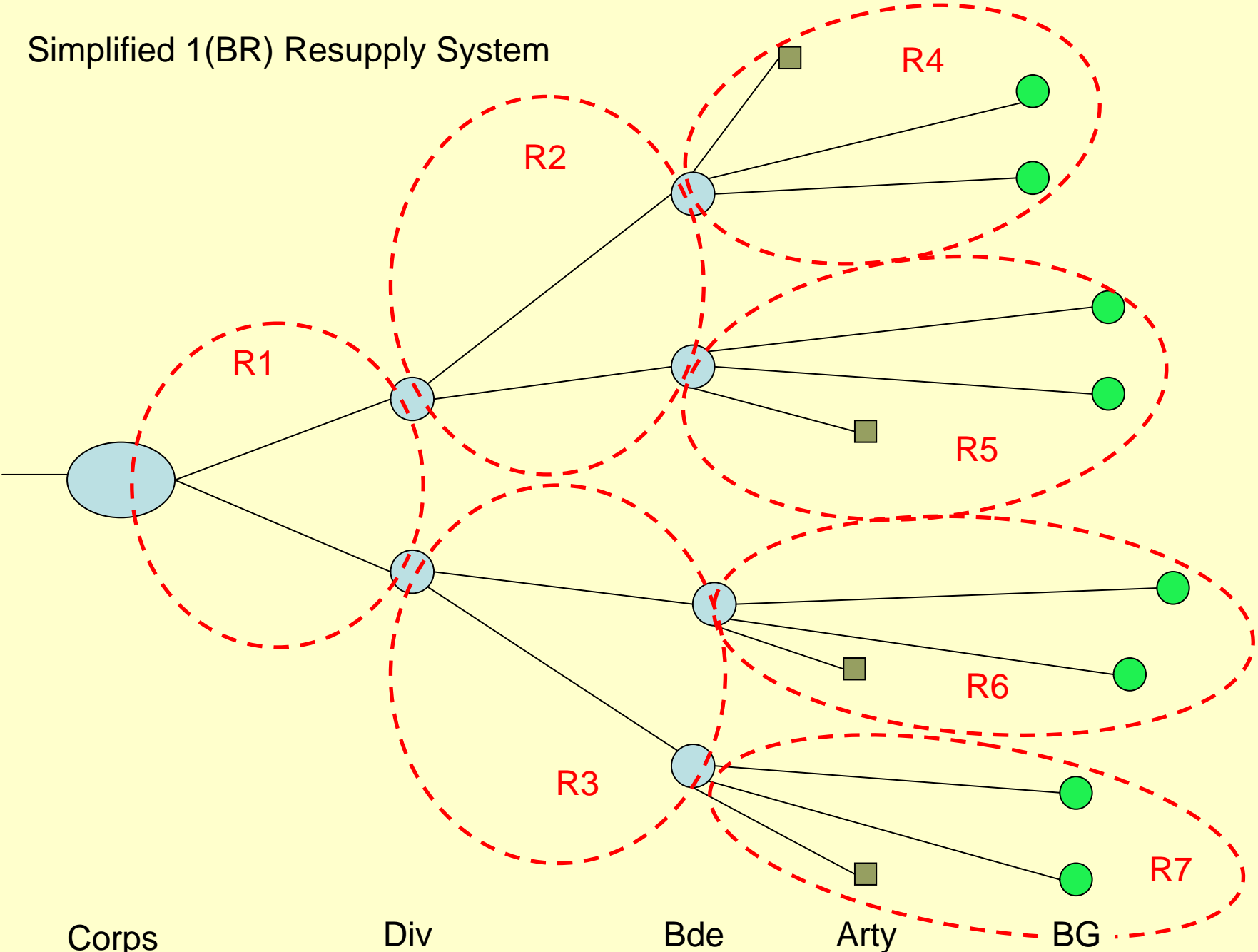
Corps   Div   Bde   Arty   BG

Objective Function

- Each front line unit and resupply point in the system had a starting stock and a required stock level. If the stock fell below this required level a shortfall was logged.

- The objective function of the model was to minimise the maximum shortfall across the system (MINIMAX).

Outcome

- The model proved to be flexible and fast running

- It enabled advice to be given to the logistic managers on the balance of transport between the different resupply regions.

- The model was used in a follow-on study that tested the ability of Warsaw Pact forces to sustain the advance rates that were predicted for them.

Reinforcement and Redeployment Modelling (1969-75)

- Determine the most economic mix of air and sea transport and pre-positioned forces and equipment to meet worldwide requirements for deployment of forces to prevent or deal with a range of threats.

- Determine how reinforcement times could be minimised with existing transport and stockpiles.
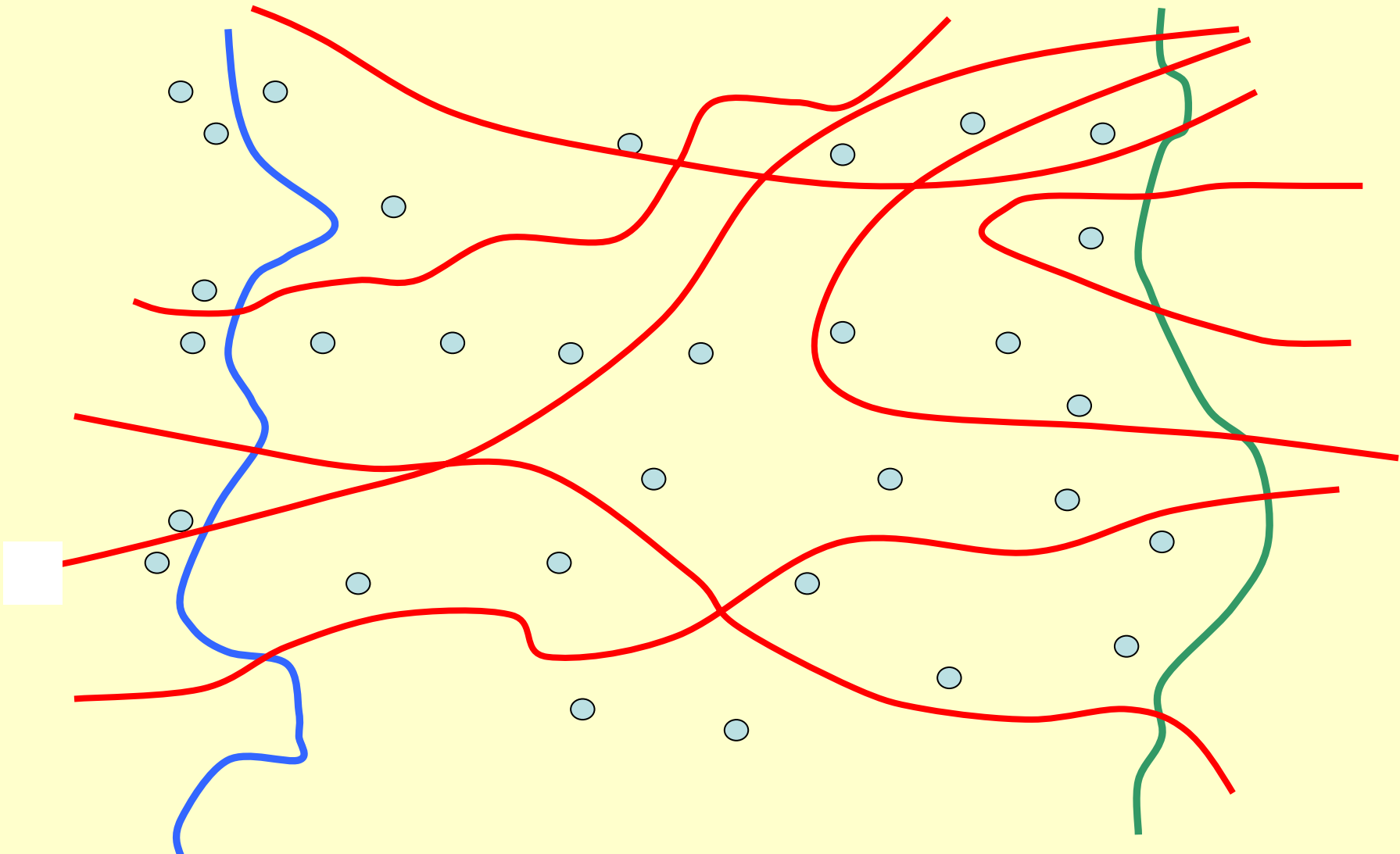
Two Problems

- The original model had been directly coded in MPS format, with the coefficients calculated by hand, and with no record of those calculations

- Need to optimise on time, but since time was a factor in many of the coefficients, to do this directly would result in a severely non-linear formulation that could not be solved

Minimising Reinforcement Times

- Varying time potentially makes problem non-linear
  - Adopt iterative approach using RHS parametrics
  - Method converges in 2 to 3 iterations

- Reinforcement times reduced from 42 days to 23 days

Air Defence Mix Study (1982-3)

- Determine the required level of investment in ground-based air defence and the optimum balance between area and point defence systems
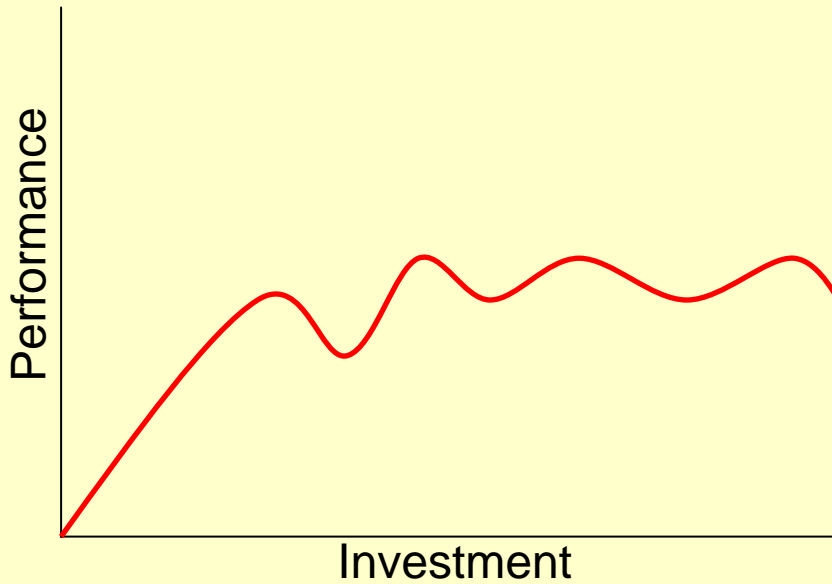
AD Sites   Red Tracks

FLOT

Study Problems

- Two issues:
  - Large number of simulation model runs required
  - Inability to select consistently good AD system deployments as investment increases

- The solution to the problem was to build a simple LP model of the allocation process.
  - objective to maximise kills against the worst track (MAXIMIN)

Performance/cost plot with manual deployment of AD systems
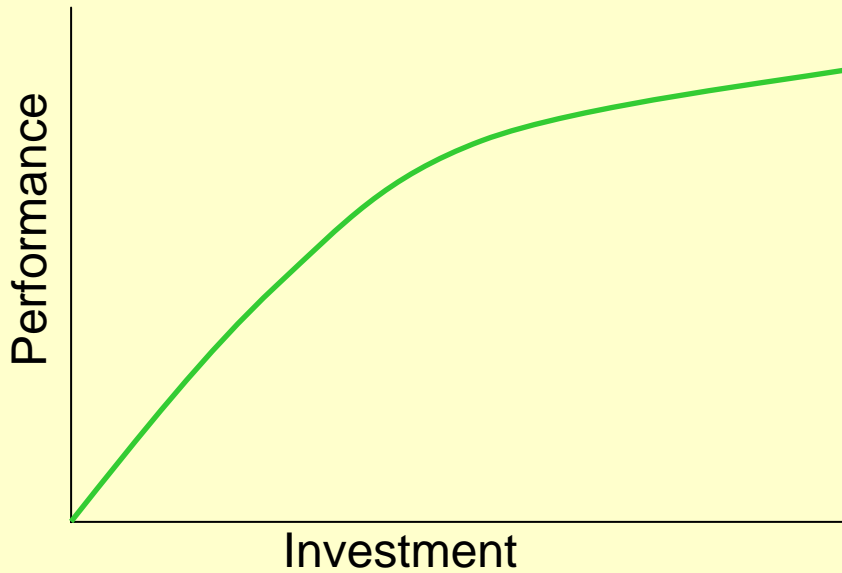
Performance/cost plot with LP-based deployment of AD systems

Benefits of LP Approach

- LP achieved consistently effective deployments that provided a more balanced defence against varying combinations of threat tracks
- LP saved a great deal of time and effort in running the simulation model

Strategic BoI Study (2007-9)

- What is the most cost-effective mix of Force Elements and Force Enablers that will enable the UK to meet the range of operations required by current Defence Policy?
  – Force elements include maritime and air platforms and land force units at company/squadron level
  – Force enablers include strategic transport, logistic support, ISTAR and C2

BoI Process
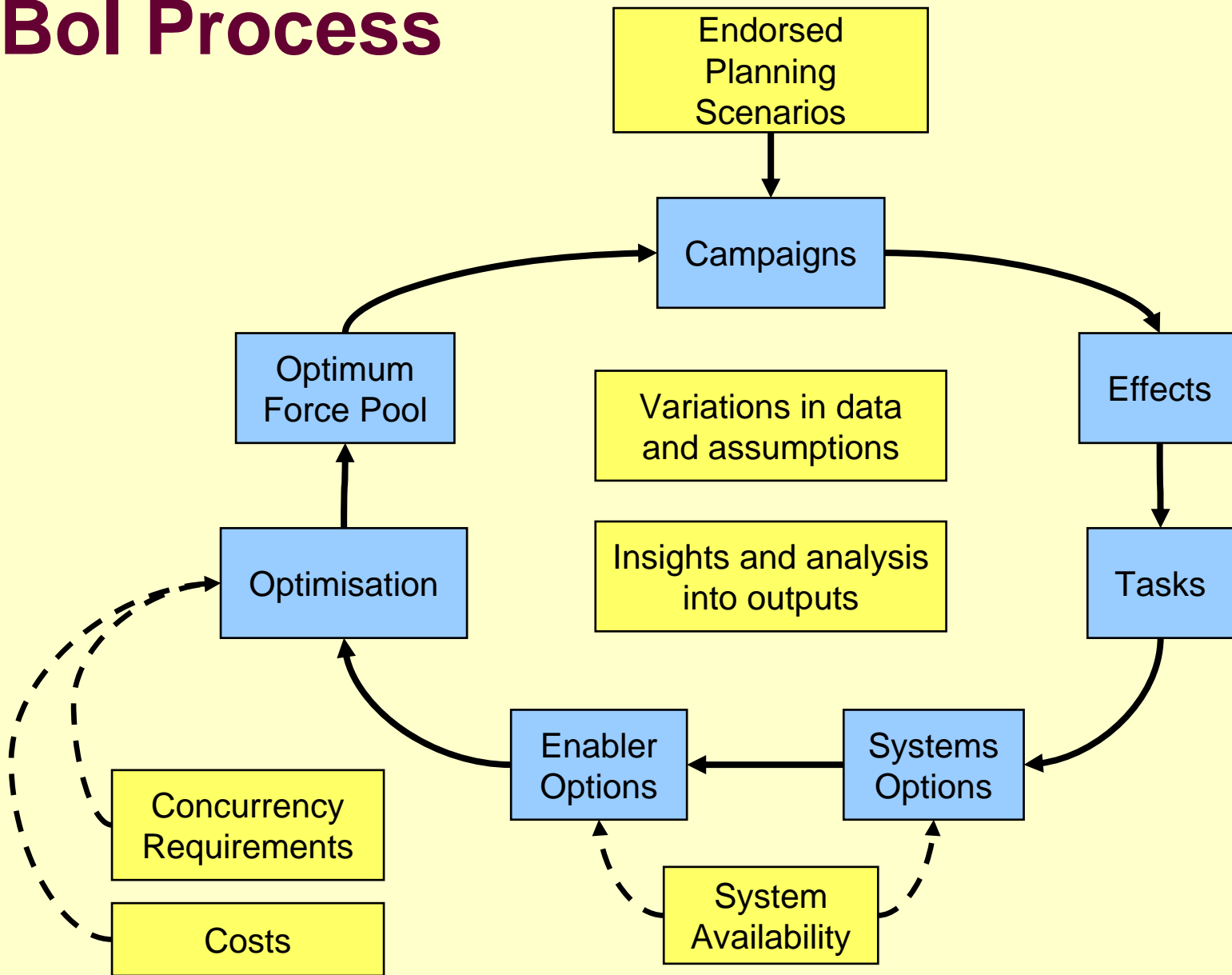
Scope of Strategic BoI LP

- The Linear Programme will simultaneously consider:
    - Force Elements and Enablers - capabilities, readiness and availability
    - Campaign Requirements by task, including enabling tasks
    - Time Frames by epoch
    - Concurrency Requirements
    - Whole life costs
- Generates the least cost force pool that will meet Policy

Conclusions

- The combination of simulation and LP offers a very powerful approach
- Options can be compared on a consistent basis
- LP models can be rapidly formulated and implemented
- RHS parametrics allow rapid exploration of the solution space
- A MAXIMIN or MINIMAX objective function provides solutions that are robust to uncertainty
- Potentially non-linear problems can be solved by using an LP formulation iteratively

Questions?