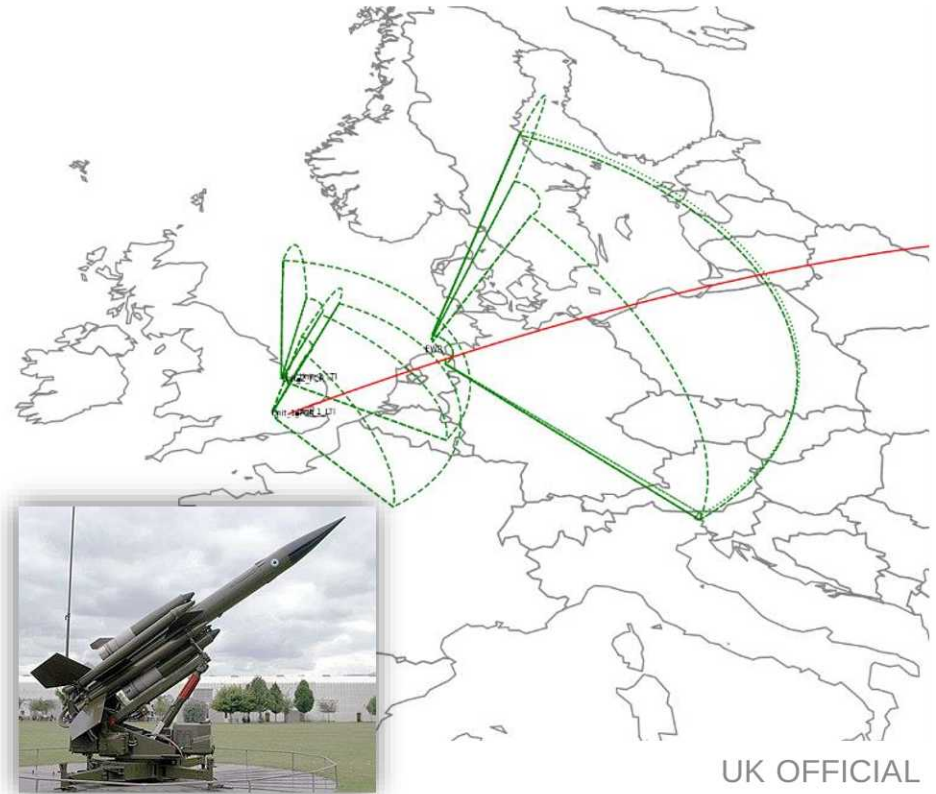


STOAT : An alternative modelling method and model for analysis and decision making

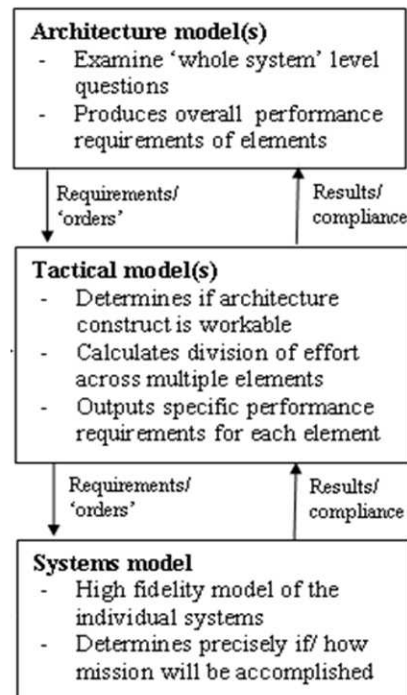
P Donnelly, T Emery, G Pickford, C Dodd
Dstl Strategic Systems Group

DSTL/PUB152225

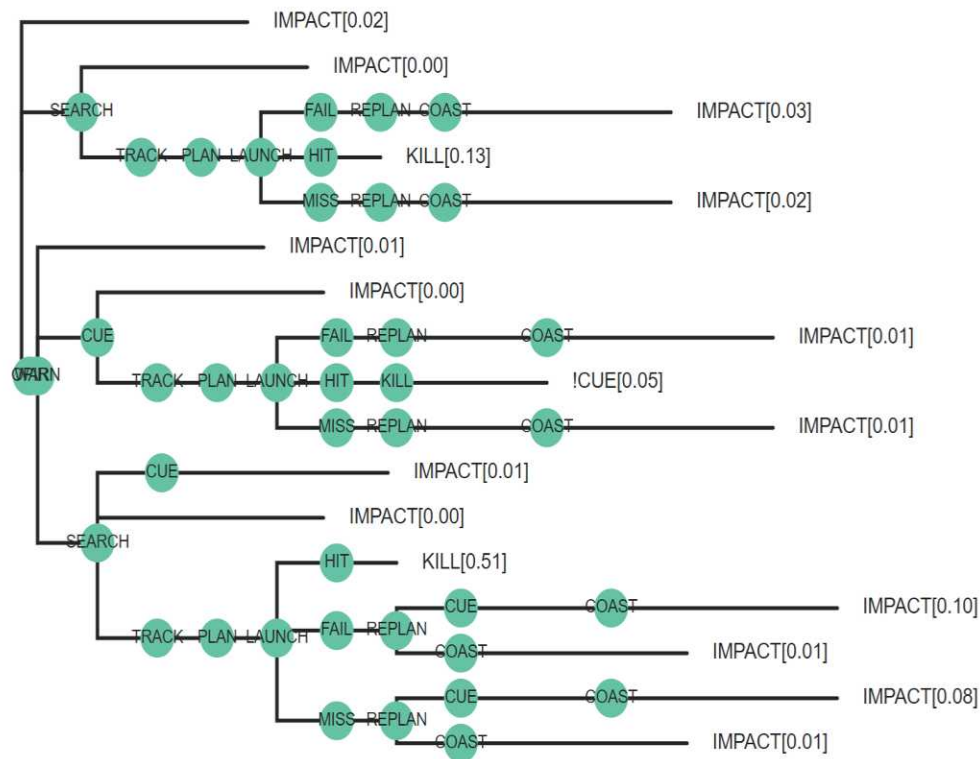
- Early Cold War example
 - 1960s Violet Friend
 - Defend RAF strategic bomber bases from a pre-emptive strike
 - (Never implemented)
- Layered missile defence architecture
 - Early warning radar,
 - Mid-course tracking radar
 - Co-located fire-control radar and interceptors
- Current systems much more sophisticated but basic principle applies

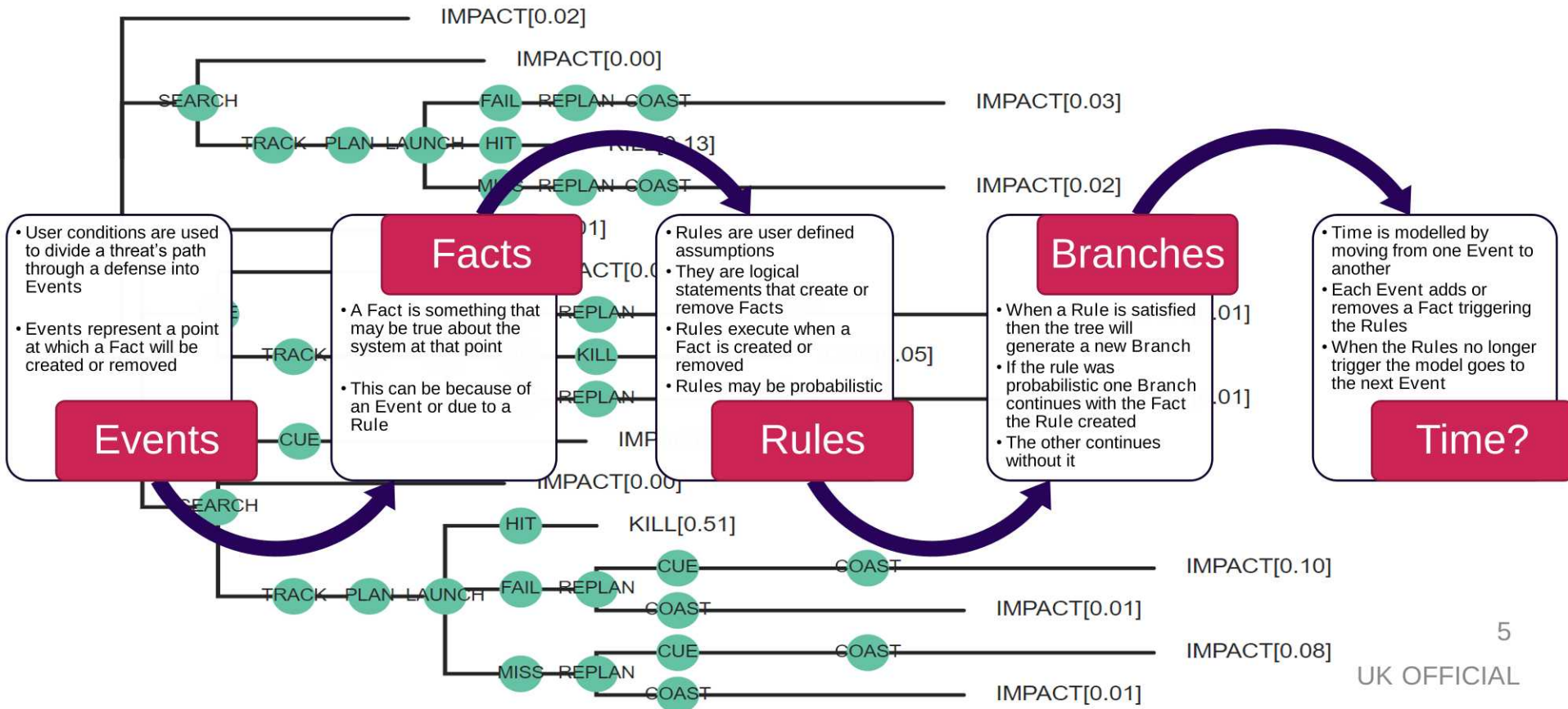


- What we do
 - Assessment of complex systems of systems
 - Assurance, effectiveness against emerging threats, impact of new sensors etc.
 - Independent advice of capability and evaluation of 'what ifs' for decision makers
- How we do it
 - Analysis, Trials, lots of Modelling
- Modelling Challenges
 - Data incomplete, inconsistent or absent (SME opinion best guess)
 - Particularly at high / medium (OA) level
 - Limited time to perform assessments
 - Monte-Carlo modelling often used to determine risk / impact of random variables, costly in computing time and complexity
 - Communication of model results and uncertainties



- STOAT (Strategic OA Tool)
 - Simple rule sets to characterise architecture.
 - Probability trees to map paths of events to different outcomes as an alternative to Monte Carlo methods





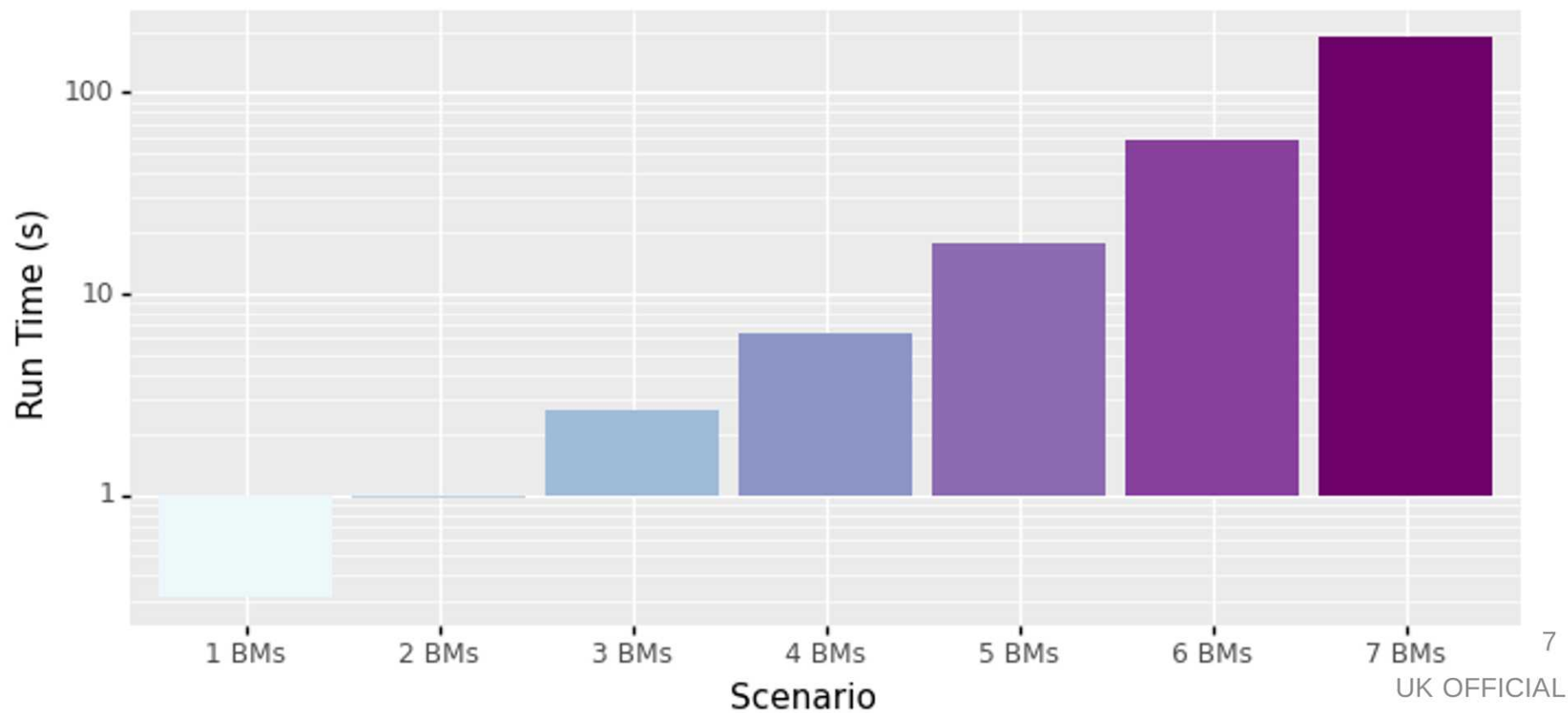
■ Modelling Approach

- Control of tree building
- No inherent BMD assumptions
- Number of computations in multi-object scenarios
- Exponential growth of tree
 - Make scalable
 - Determine impact on fidelity
 - Investigate limits of practicality

■ Communication

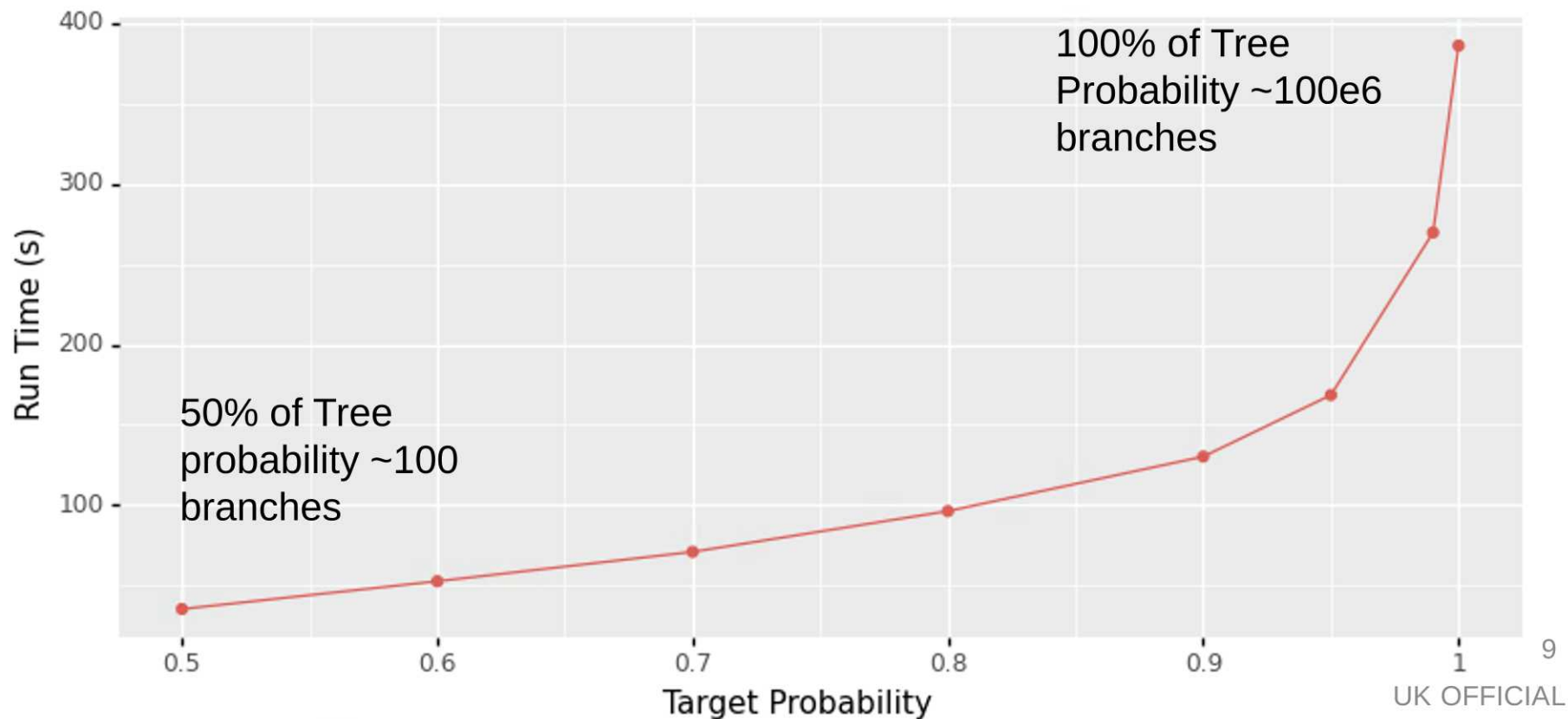
- Understanding implications and differences to conventional approach
- Interpreting results
- Communication of results and impact of uncertainties

Example of Rapid Scaling



- Combination alternative to Permutation
 - STOAT originally operated with Permutation branching.
 - i.e. Events and Objects are always distinguishable and the order they occur matters
 - Combinatorial branching for operations where objects can be treated as indistinguishable can be performed much quicker with less branches
- Dispatcher to Control (sparse) Tree Evaluation
 - The dispatcher handles controlled trimming of the ever-multiplying branches and breaks the recursive behaviour of trees.
 - Branches to evaluate are now selected from the set of all possible pending branches by user defined criteria.
 - Typically this is picking a set number of branches with the highest probability at a given depth in the tree.
 - Execution can continue until e.g.
 - A time limit is reached.
 - This is potentially powerful and useful!
 - But of course, there is not a free lunch.....

Probability Targets (7 Ballistic Missiles)



- Large complexity studies can now be performed, albeit with sparse output trees.

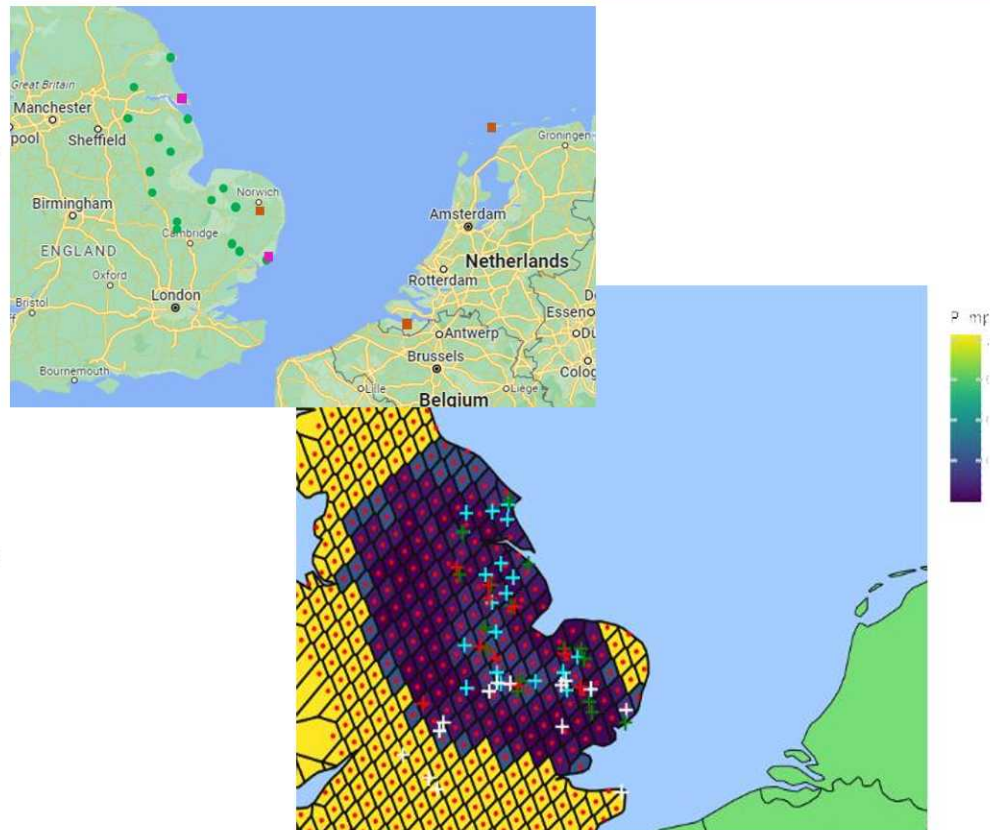
- However,
 - The interpretation of sparse output trees requires care.

 - The use of probability in STOAT is different to traditional Monte Carlo models, further investigation and ways of communication of uncertainties is being undertaken

 - The potential for bias in outcomes also exists.
 - Always picking the highest probability branches may systematically exclude particular outcomes.
 - Certain low probability branches may be important outcomes

■ Modelled in STOAT

- Using open source legacy information of radar sites and interceptor locations and capabilities
- Modeller makes assumptions about how radar and interceptors operate and interact
- Can investigate effect of different operation and tactics on defended areas
 - Quite extensive architecture rapidly modelled on sparse legacy data
 - Assumptions clear and sensitivities can be shown



- STOAT
 - Alternative to Monte-Carlo modelling
 - Looks feasible, fast, flexible
 - Studies can be scaled to time/resources available with known coverage

- Investigating the differences between STOAT and Monte-Carlo
 - Comparison with established models (Outcomes and statistics)
 - Development of ways to communicate the differences

- Wider engagement
 - Understand applicability
 - Perhaps assist in V&V where data more widely available
 - Contact ttemery@dstl.gov.uk



[dstl] The Science Inside

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