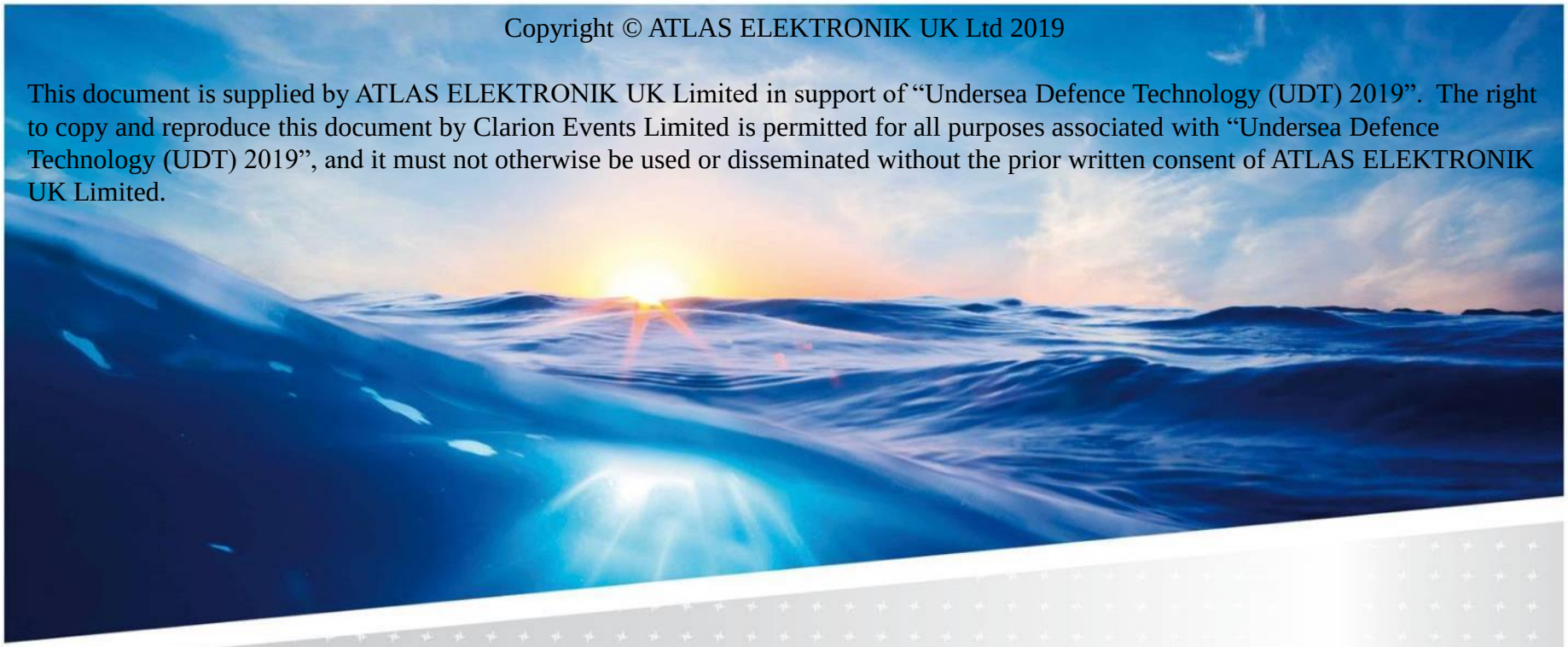


MCM planning and evaluation for a UxV Toolbox in a variable mine threat and environment

R Brothers

February 2019, AEUK/19/0640

ATLAS ELEKTRONIK UK
A company of the ATLAS ELEKTRONIK Group

...a sound decision

Background

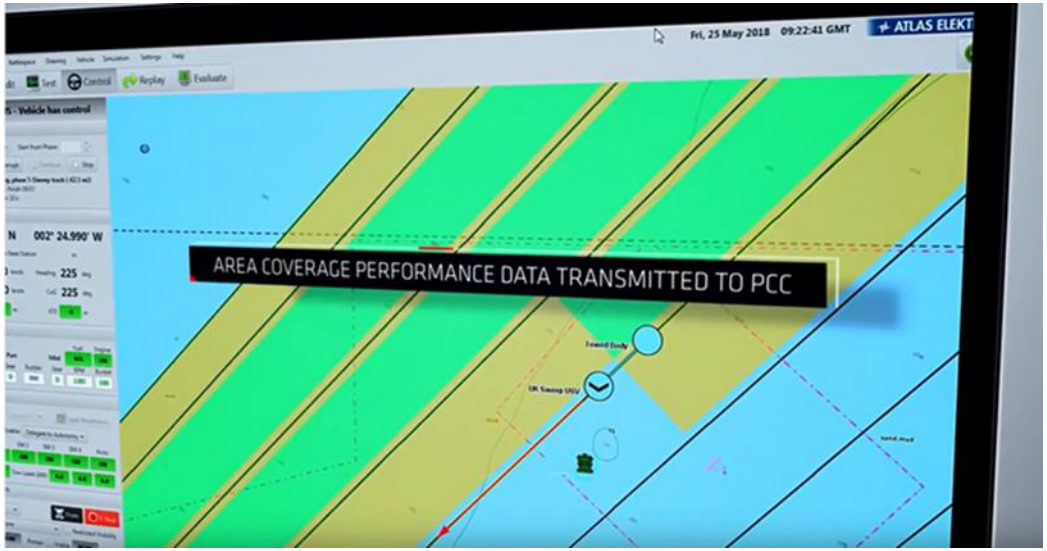
- The use of UxVs for MCM is rapidly increasing
  - There are a range of systems becoming available for UxV mine sweeping and mine hunting to suit a range of budgets
  - The key for each customer is to use their toolbox of systems to best MCM effect, and understand that effect
- A problem exists however, in that traditional MCM planning and evaluation (P&E) processes are not readily useful with UxVs

Problems with traditional P&E

- Traditional P&E process generally examine across-channel (1D) performance, so that performance variability P(y) can only be assessed for mission legs parallel to channel
  - This does not reflect the flexibility of UxVs to operate legs from multiple angles
  - Parameter simplification difficult for UxV legs oblique to the channel
- Traditional planning for mine hunting UUVs does not always consider mine knowledge (i.e. leg spacing is based on default sonar swath) i.e. P(y) is not readily used
  - Unlike traditional MCMV-based mine hunting, unlike UK Sweep TDA
- Detection and classification phases are not separate for high-resolution imaging sonars
  - P(y) needs to account for both, and a new modelling approach is required
- Coverage of MCMV sonars and UxV sonars are different
  - Although statistically equal, is full spatial coverage at lower relative performance the same as incomplete spatial coverage a relatively high performance?

2D coverage mapping

- AEUK have been promoting a 2D coverage mapping approach for MCM UxV P&E for some time
- Basic coverage mapping is included within the UK Sweep TDA, with optimum P(y) based on intelligence (modelled by TMSS) and mapped to UxV tracks



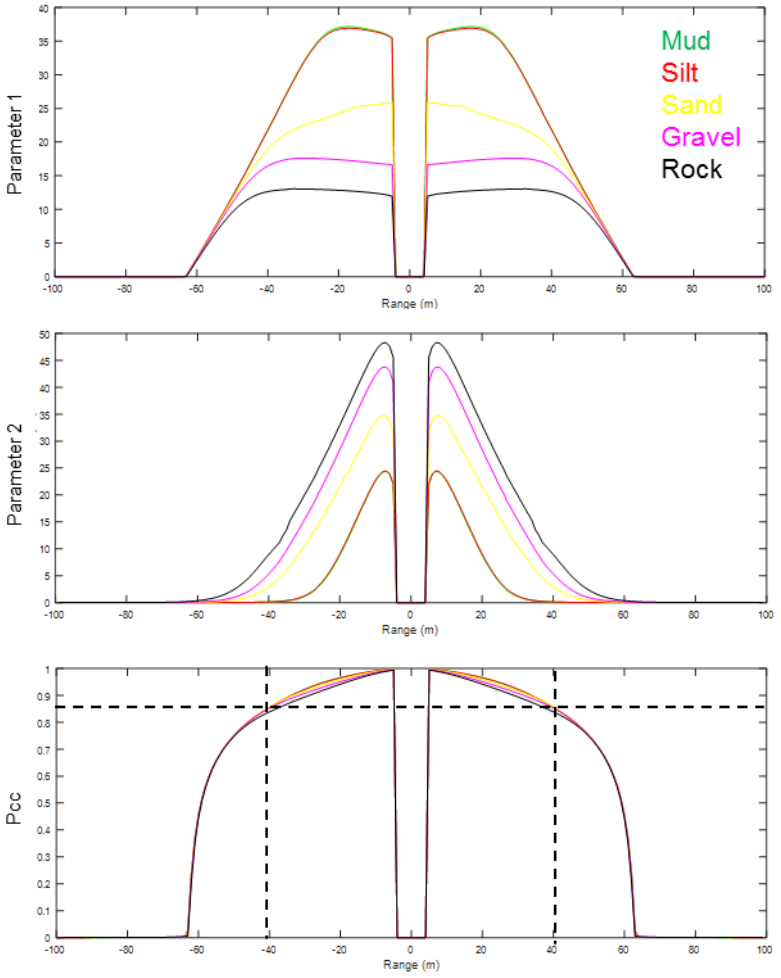
New developments

- In order to address the shortfalls of traditional P&E processes in use with UxVs, AEUK conducted an internal Innovation task to develop 2D coverage mapping Matlab software to highlight the benefits
  - Use of an Information-based Johnson's criteria model to calculate UxV sonar P(y) based on mine and environment parameters (inc. 2D environment if available)
  - 2D coverage mapping (including environmental variation) based on planned and/or achieved tracks (any orientation)
  - Incorporation of through-the-sensor 2D missed coverage in evaluation
  - Ability to evaluate mission over time
  - Can be used with Bayes theorem for traditional MCM evaluation or with CONEMPs based only on spatial coverage

UxV sonar P(y) modelling

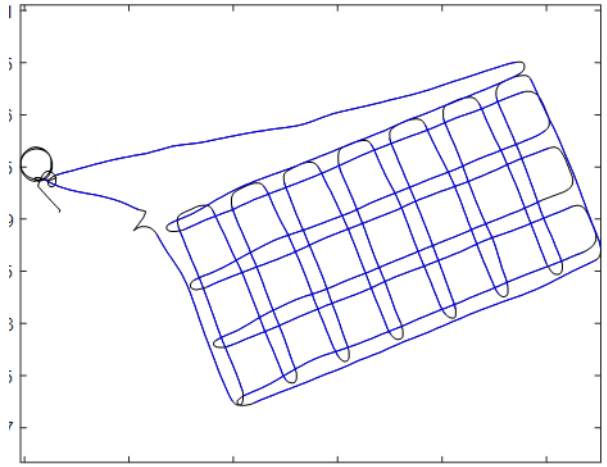
- AEUK have adapted an Information based model to estimate imaging sonar performance
  - Predicts the results of operator simultaneous detection + classification
  - P(y) - Pcc versus range
    - Determine effective swath

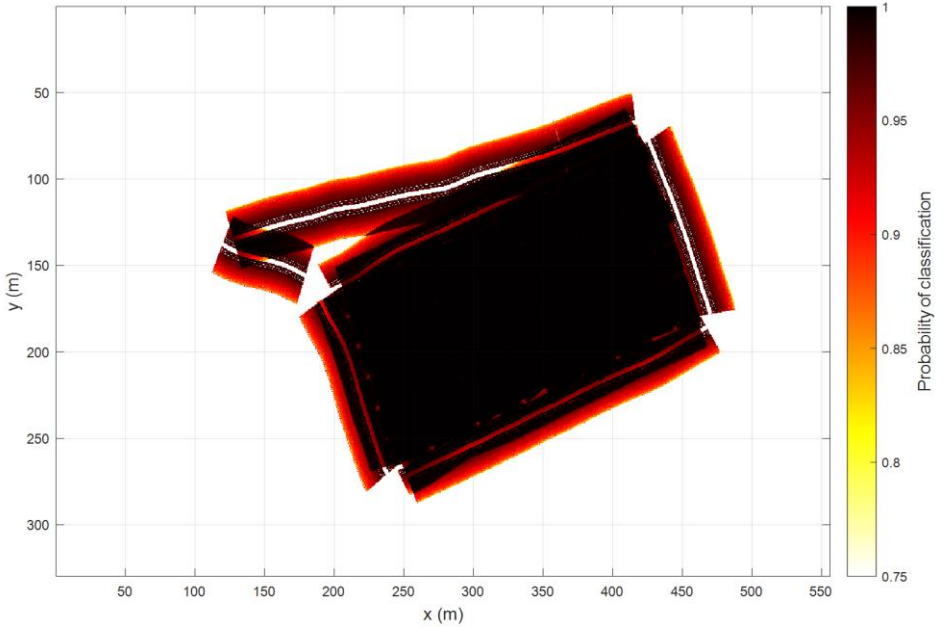
COTS UUV sidescan sonar vs small bottom object (<1 m dimensions)



2D coverage mapping

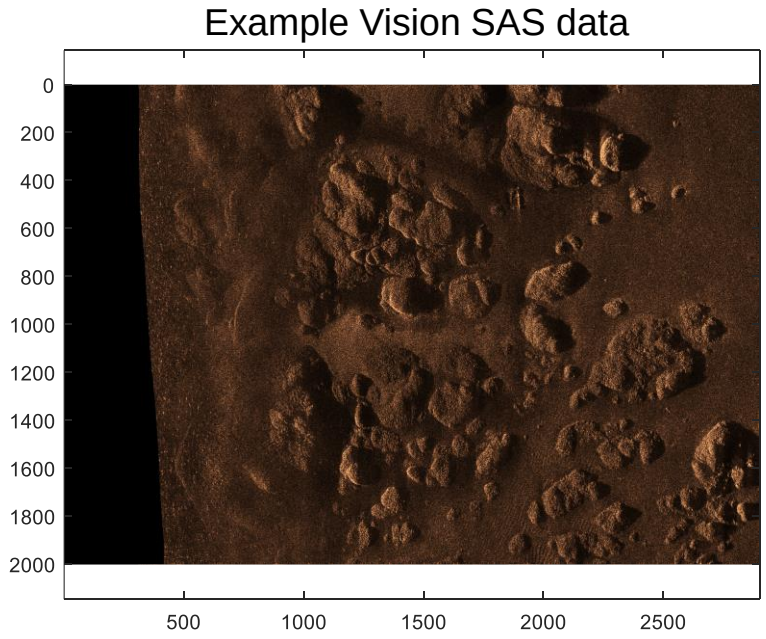
- Use UxV track and heading data (planned or achieved) to map P(y) curve to 2D grid – P(x,y)
  - Map P(y) swath (from Information-based model or measurement) to leg tracks
  - Cumulative (independent) coverage e.g. $P_{cum} = 1 – ((1-P_n)(1-P_{n+1})...)$
  - Coverage mapping can overlay charts etc. in GIS
  - Evaluate coverage in channel or area

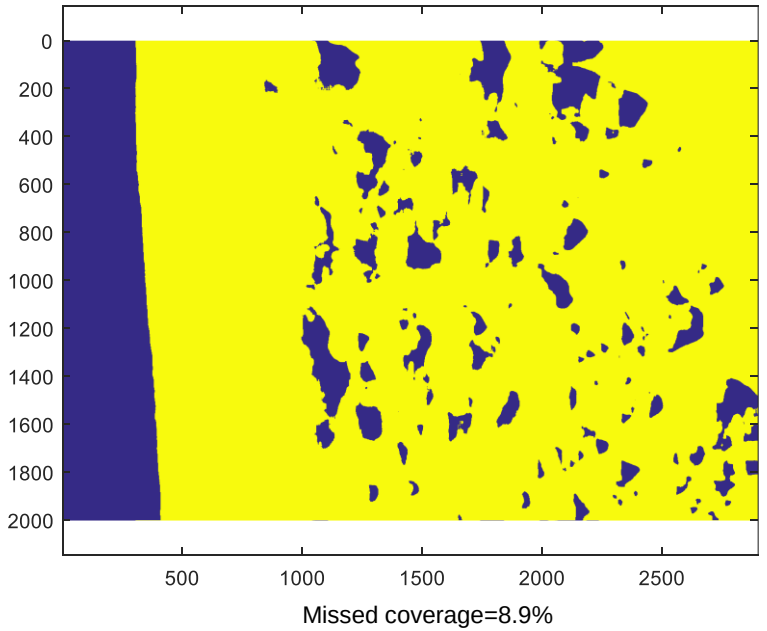




Mapping missed coverage in-mission

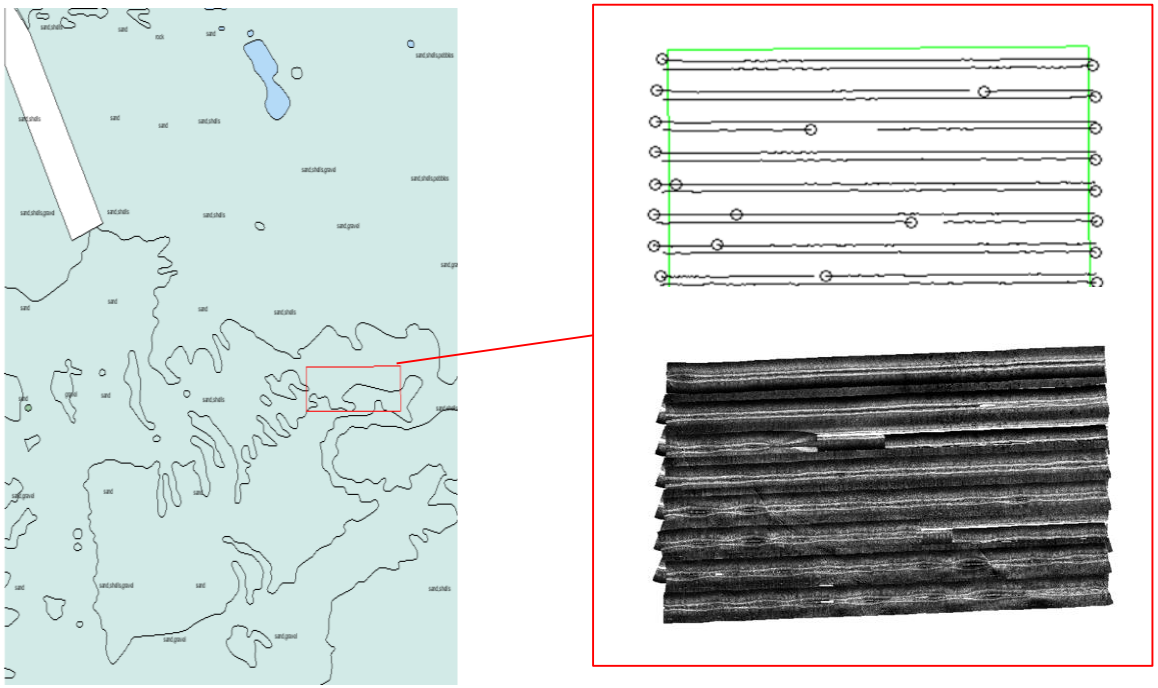
- AEUK have developed an adaptive technique for auto-mapping of missed coverage in sidescan sonar/SAS imagery
- This can be accounted for in evaluation of achieved mission coverage





Use of GEOINT

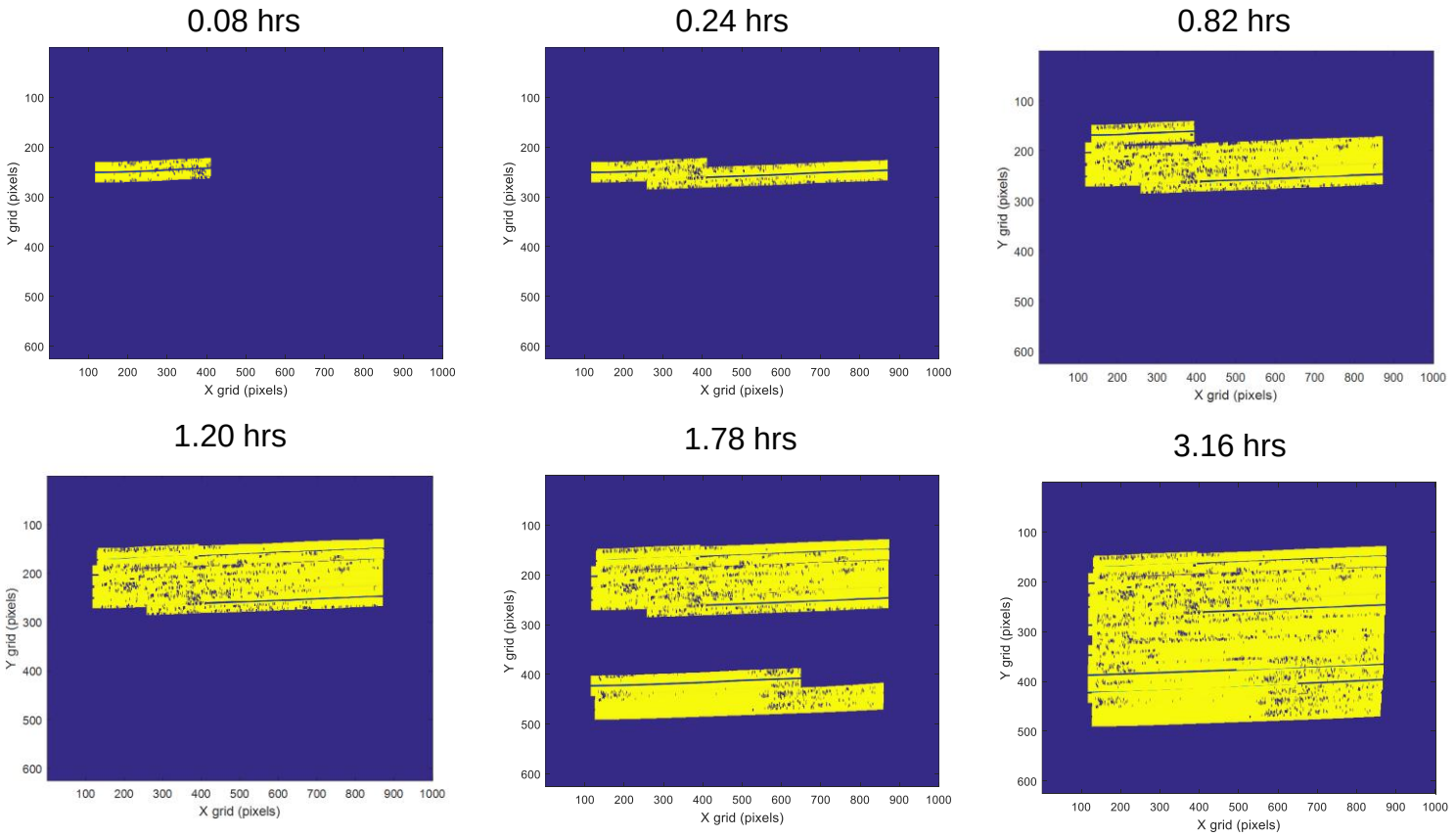
- The 2D coverage mapping process is inherently suited to exploit modern chart-based GEOINT (e.g. AML etc.)
  - These can be exploited as part of the coverage mapping – (e.g. modifying P(x,y) based on seabed type)



Example mission in rough seabed area, with “broken” legs, and non-uniform coverage

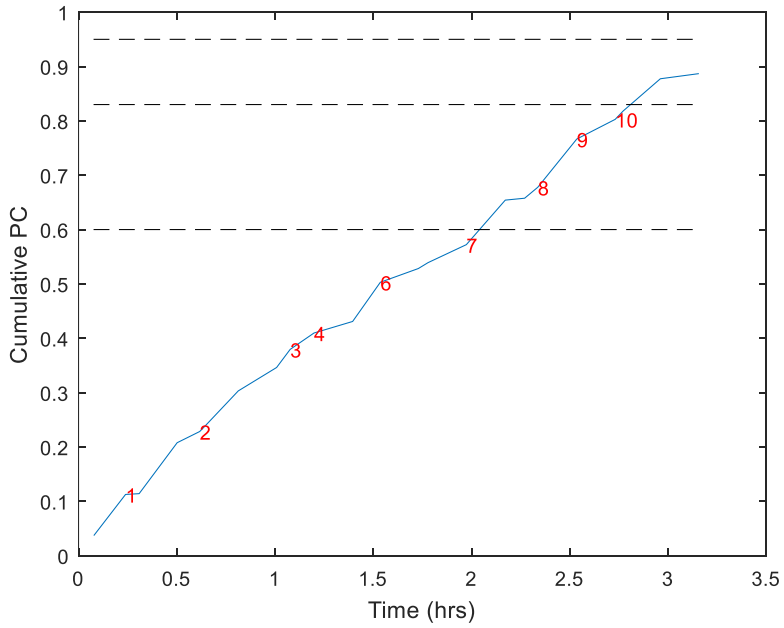
Time evolution of mission (1)

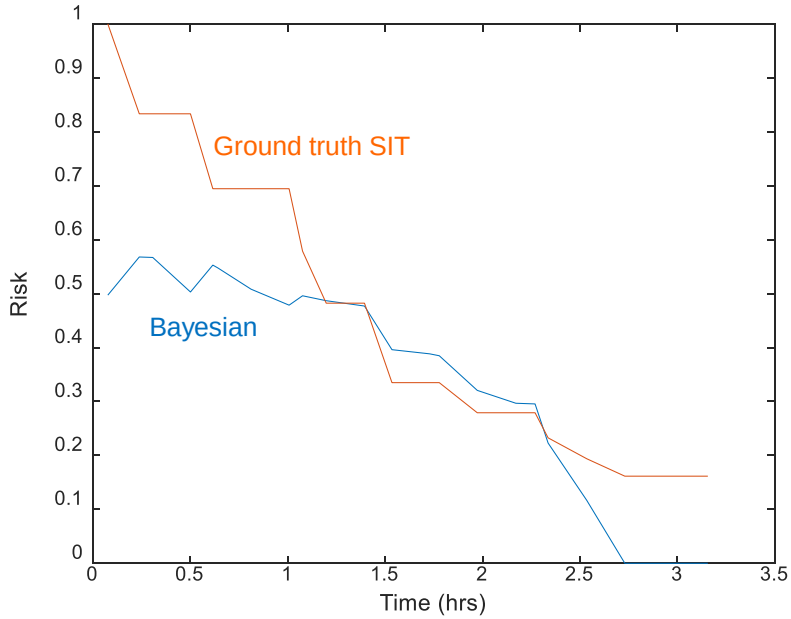
- By evaluating a mission leg by leg (or in smaller segments if required), a time evolution of MCM performance can be evaluated



Time evolution of mission (2)

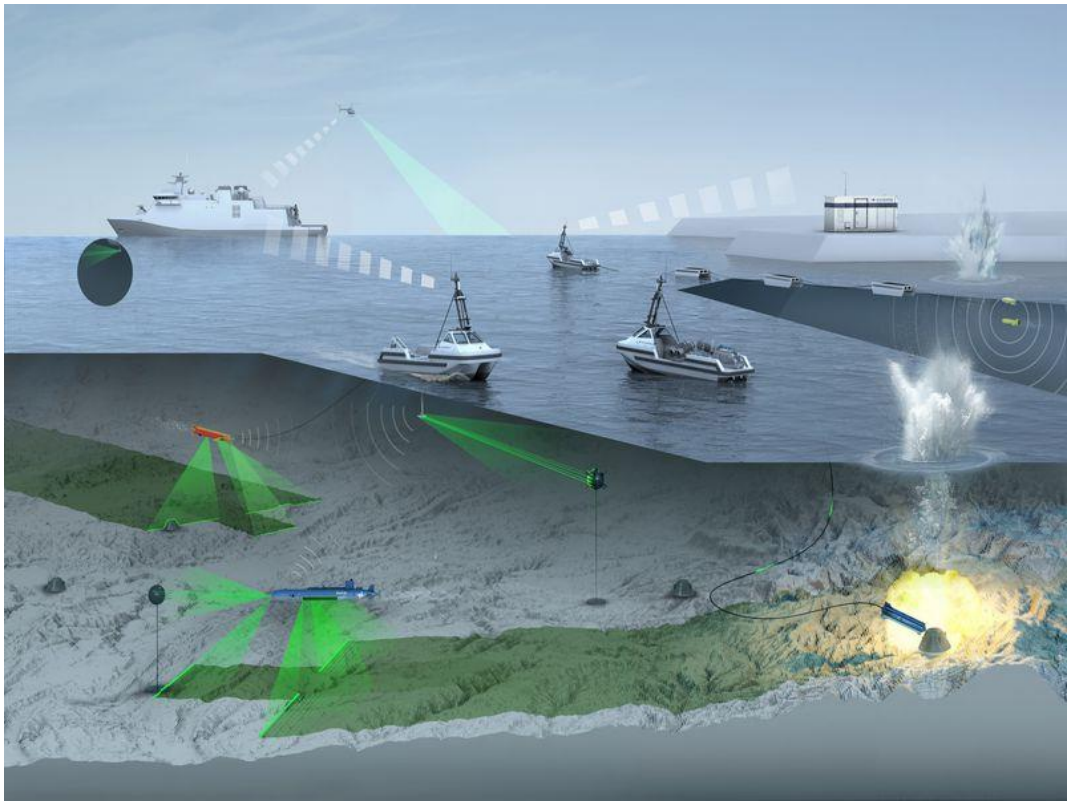
- Reports of mine finds throughout the mission (e.g. from MCM USV system) can enable an evolving Bayesian approach of determining the *a-priori* distribution of mines and estimation of risk remaining versus time





Percentage clearance and combined MCM

- Coverage mapping for both mine sweeping and mine hunting (assuming subsequent disposal) both represent a “percentage clearance”
- Consequently, the effects of both can be readily combined in P&E
- This introduces a range of combined MCM tactics that can be employed (and evaluated)
  - e.g. mine hunting followed by mine sweeping lead through
  - e.g. directed mine sweeping for mine disposal following mine search



Managing uncertainty

- This end-to-end process is capable of accounting for uncertainty in:
  - Environment
  - Mine information (type, numbers and probability of location)
- To represent the combined uncertainty, upper and lower bounds can be readily investigated together with metrics to quantify levels of uncertainty

Summary

- AEUK have a developed a 2D coverage mapping process that can form the basis of an end-to-end P&E process for MCM UxV toolboxes
  - Based on mine and environment intelligence (modern GEOINT products)
  - Accounts for UxV manoeuvrability
  - As mapping based on “% clearance” only can account for mine hunting + mine sweeping – opening up a range of MCM tactics
  - Accounts for through-the-sensor missed coverage in evaluation
- This enables customers with variable budgets, and varied toolboxes to exploit them to best MCM effect

Contact

ATLAS ELEKTRONIK UK Ltd.
Dorset Green Innovation Park
Winfrith Newburgh
Dorchester • DT2 8ZB
United Kingdom
Phone: +44 (0) 1305 212400
www.uk.atlas-elektronik.com

ATLAS ELEKTRONIK UK
A company of the ATLAS ELEKTRONIK Group