DIN STRATEGIC INVESTMENT INITIATIVE
AUTOMATED TASKING OF RAS TEAMS FOR ACTIVE MODELLING OF CBRN THREATS

SCENARIO – CHEMICAL ATTACK DURING OPERATIONS IN CONTESTED ENVIRONMENTS

ADF units are operating in a contested non-urban environment – consider a relevant area of operation of 1-10 sq. km. Several disjoint alerts of an airborne chemical hazard have been raised in the operational area, from ground-based sensors (on personnel, vehicles, infrastructure). Current battlespace management software highlights these alerts and establishes coarse but possibly disjoint 'no-go' zones around them. Sensing is not 100% reliable and hence alerts may be inaccurate or erroneous. The source(s) of the hazard are initially unknown. Only sparse, wide-area atmospheric forecast data is available. How ADF personnel in the operational area respond will depend on their understanding of the threat that a hazard may impose on themselves, on other units, coalition partners, the civilian population in the area and the mission.

PROBLEM STATEMENT – ENHANCED SITUATIONAL AWARENESS OF THE IMPACT OF CBRN HAZARDS

Field commanders and decision makers who are not necessarily expert CBRN analysts require an accurate threat model – a representation of the impact of a hazard on freedom of manoeuvre, and the health and safety of personnel, equipment and infrastructure. Such a model depends on measuring the extent of the hazard, its intensity and variability (in space and time) and transforming these data into measures of impact. As the context evolves so too should the threat model.

The Department of Defence OCE[1] STaR Shot's developmental Active Collaborative CBRN Environmental Sense and Sense-making System (ACCESSS) proposes the use of teams of (potentially heterogeneous) low cost RAS[2] platforms carrying low SWAP-C[3] chemical and environment sensors for active sensing in the above scenario, to build enhanced situational awareness for operations in CBRN environments. Human tasking of RAS assets and human-centric modelling and analysis is infeasible in all but the most trivial of scenarios.

The problem owners are concerned with when, where and why RAS platforms are deployed, and what these platforms then do to collect data. They require a system that automatically tasks RAS assets carrying appropriate sensors based on the information needs of a threat model, the current hazard data state and the required data needed to build, update or complete a threat model. Tasking should be optimal with regards to system performance metrics, which may be proposed. Data gathered by RAS-based sensors supports model updating, which may dictate further sensor tasking. This closed loop process should ensure errors and uncertainties are bounded in time in dynamic scenarios, given appropriate resources.

[1] OCE – Operating in CBRN Environments
[2] Robotic and Autonomous Systems
[3] SWAP-C – Space, Weight, Power and Cost

NEED & RELEVANCE TO DEFENCE – PRESERVING FREEDOM OF MANOEUVRE IN CBRN ENVIRONMENTS

The threat of encountering CBRN hazards in military theatres of operation is very real. Agile Command and Control (C2) requires timely, precise, and robust information to support effective and efficient response to and management of CBRN threats. High fidelity digital representations of CBRN hazards, underpinned by active sensing and automated methods of tasking RAS assets, will ensure risk-based decision making is based on (near to) real time analysis of available and acquirable data.

RESEARCH QUESTIONS

What is an appropriate representation of threat for the above scenario? How does ACCESSS automatically select and task RAS assets to collect data for building and refining a threat model? What sensing capabilities are required to solve this problem? How is platform performance and manoeuvre capability related to data gathering capability and reliability? How does performance of individual platforms and sensors impact the modelling of threat over wide areas and extended temporal extent? How is modelling limited by bounded energy constraints per platform? How does the system cope with/adapt to platform/sensor failure and error? How should RAS platforms behave - are they goal-directed or behaviour-based? How will data gathering requirements be extracted from an incomplete or uncertain threat model? How are requirements translated into RAS plans/behaviours? What are sources of uncertainty in this system and how does uncertainty impact system performance? Are there risk-aware data gathering strategies suitable for this modelling problem? Is there an information theoretic or mathematically optimal way to determine the best tasking solution for a given model and scenario?

OUTCOMES

A solution to this problem will consist of:

1) modelling methods (data structures and algorithms) for representing threat over an operational environment, given sampled hazard data;
2) an algorithm for near real-time updating of threat models based on new data obtained from RAS assets;
3) an algorithm for tasking RAS assets to support optimal data gathering given model update requirements;
4) algorithms for autonomous execution of task plans/behaviours by RAS platforms;
5) measures of system performance and algorithms to evaluate these measures.

The solution must be demonstrated in live field trials under the following conditions. Assume an augmented reality chemical hazard scenario in a real environment - i.e., a virtualised representation of a chemical hazard in a defined real physical environment, with virtualised sensors to extract simulated hazard data at physical locations reported by GPS devices on RAS platforms. Multiple RAS platforms should be tasked according to the outputs of designed algorithms, with demonstrated capability of tasking and executing simultaneous operations of multiple platforms. Sensor data must be incorporated to update the threat model. Ideally, further sensor tasking should be justified based on the updated model. The demonstration should facilitate an understanding of the capabilities and limitations of the system, and operational constraints that apply.
Note: there are existing industry solutions for an augmented reality hardware-in-the-loop simulation of CBRN hazards, so this is not part of the deliverables for this project. Proposals under this call should consider engagement with suitable partners for this capability.