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SAPIENT

for Multi-Object Tracking and Decentralised Processing

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Ministry of Defence

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SAPIENT Concept

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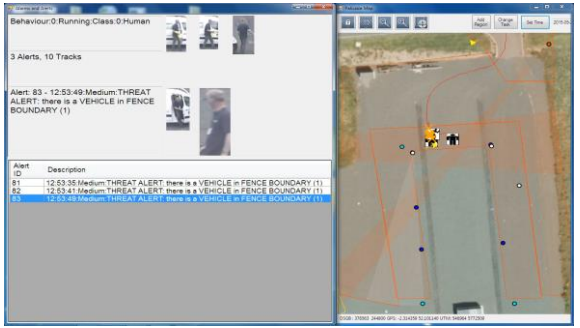
Modular sensor network, incorporating autonomous sensing, processing and fusion

Develop capability: from this…

- Raw data is piped continuously to the analyst;
- Relies on human cognition for detection, Threat-assessment and Sensor-management;
- Users experience “vigilance decrement” over time;
- Problem compounded by low operator to screen ratio;
- Data overload.

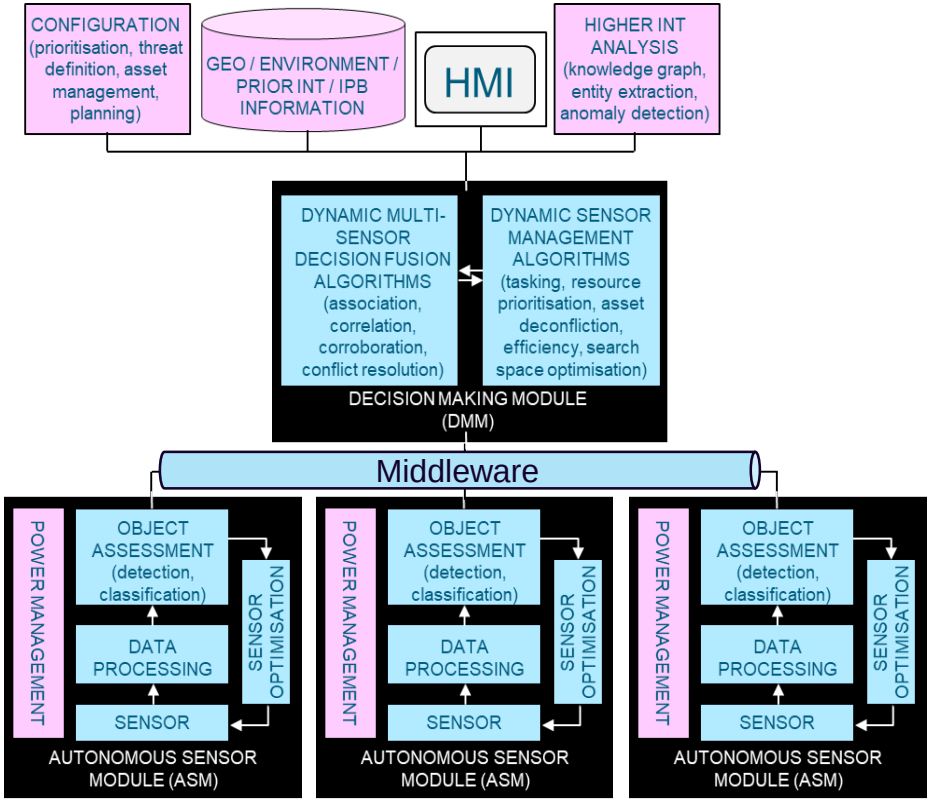
… to this



- Multiple sensor modalities
- Acting autonomously with overall coordination
- Analyst is detached from individual sensing modalities
- Sensor suite provides persistent coverage, robust to individual failures
- **Supplying information rather than raw data to the user / analyst**

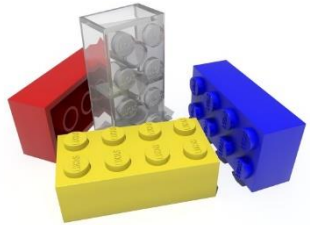
Architectural concept

- Modular
  - Autonomous Sensor Modules (ASMs)
  - Decision Making Module (DMM)
  - Middleware
  - HMI / GUI
- ASMs convert raw data to common message format.
- Common but flexible. Can declare:
  - Detections
  - Tracks
  - Classification
  - Behaviour
- DMM is agnostic to sensor type.
- ASMs are plug-and-play.
- Sensor management is integral.



Key architecture requirements

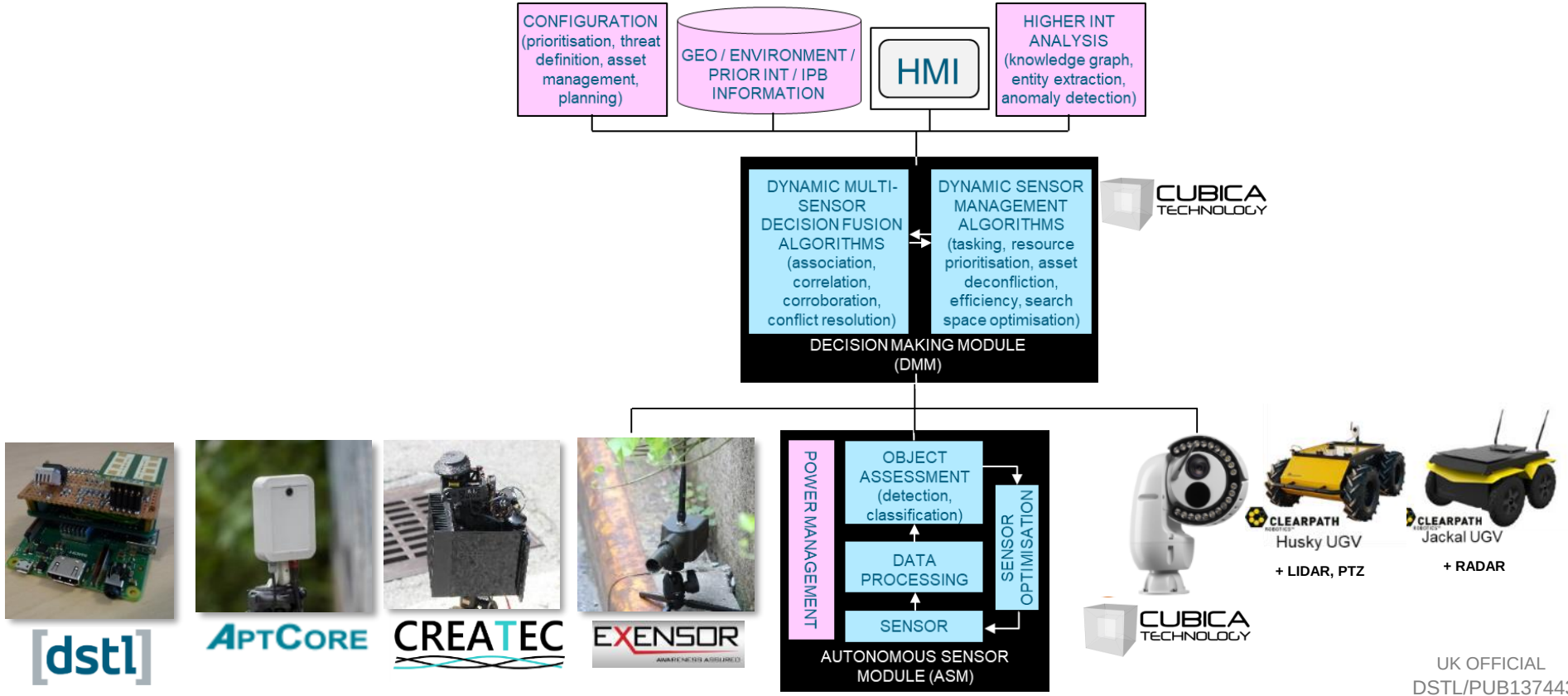
- MOD-owned, open-architecture



- Component modularity

- Reduced bandwidth requirements

Instantiations



Base Protection Demonstration (2015)

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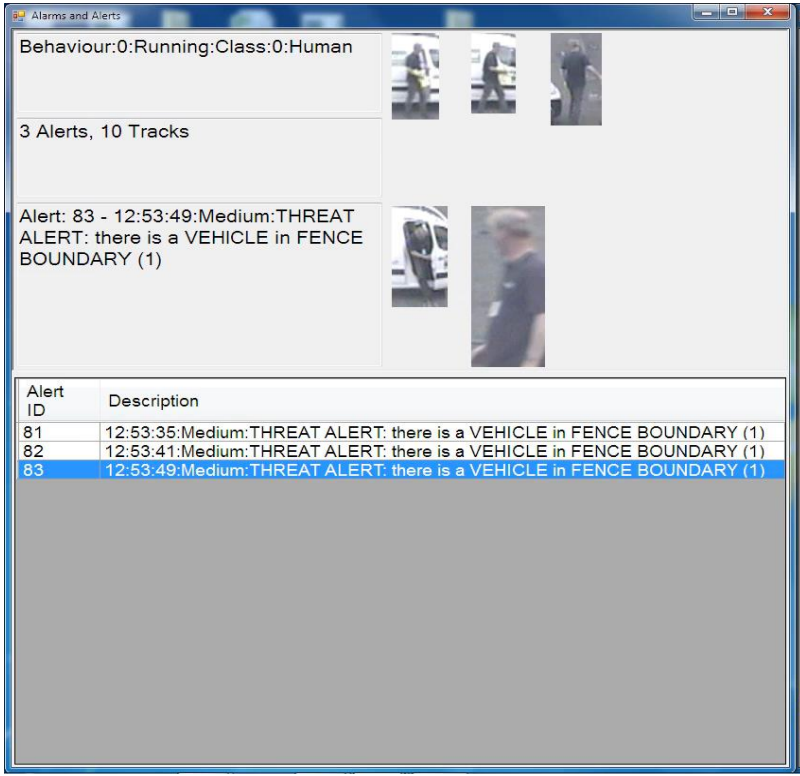
Concept Demonstration

- TRL 4-5
- Aligned to perimeter security scenario
- Live targets and sensors
- Objectives were to demonstrate:
  - Sensor Autonomy
  - Decision Fusion
  - Sensor Management
  - Low-bandwidth system
  - Low-operator burden



DMM – integrated multi-type fusion

Use-cases / Demonstrations

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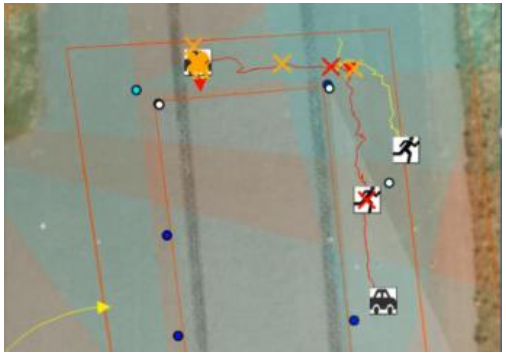
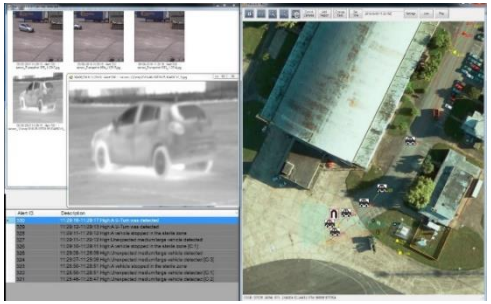
Perimeter protection (2015)



Area Denial (2016)

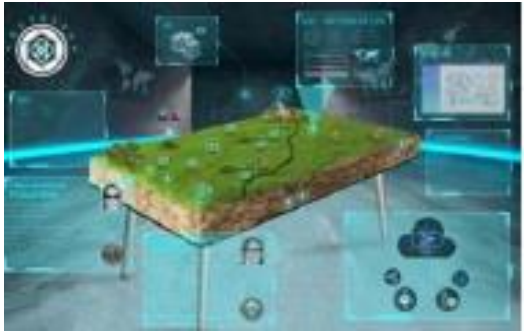


Contested Urban Environment (2018)

Contested Urban Environment (2019)

Counter UAS (2017)

Integration with NEBULA (2020)



The CUE2021 Experiment

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- CUE20 Postponed due to CV-19
- 27 September – 15 October 2021
- 5+ nations
- 60+ technologies
- 100+ S&T personnel
- 50+ military personnel
- 45+ partner organisations

Locations across Portsmouth will be in use including HMNB Portsmouth, Fort Blockhouse, Fort Widley and locations across the city

Experimental Hypotheses

- Exploitation of ubiquitous urban data sources
- Wide-area ISR and decision support
- 3D situational awareness in complex urban areas

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SAPIENT @ CUE 2020

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DIET (Deployed ISR Experimentation Testbed) is a containerised facility that allows SAPIENT, with a collection of multi-modal tactical sensors, to deploy quickly to realistic environments.

Sensor – Radar

The AptCore sensor uses 24 GHz radar to determine the range, Doppler speed and direction of objects within the Field Of View (FOV). with good accuracy.
The radar is capable of measuring the range and Doppler speed of multiple objects. The system will classify objects as vehicles or pedestrians within a FOV of 80°. The radar is able to resolve the direction of multiple objects at each range,

Sensor – PTZ

The Cubica Pan Tilt Zoom (PTZ) camera is based on a RobotEye rapid slew-rate optical system. This incorporates an HD colour daylight camera
With a 2.1 megapixel 1/2.8" CMOS Focal plane providing 1920 x 1080 pixels @ 25 fps. These images are processed by local AI algorithms to extract and classify targets, sending SAPIENT compatible detection and alert messages.

Sensor – SLATE

SLATE uses a Scanning Laser Rangefinder that provides precise (<1cm) positions, sizes, shapes and velocities of objects within the field-of-view (FoV), providing shape, tracking and description to enable intelligent object recognition. Moving objects are automatically separated from the background then tracked and classified, enabling precise shapes, sizes and velocities to be measured.

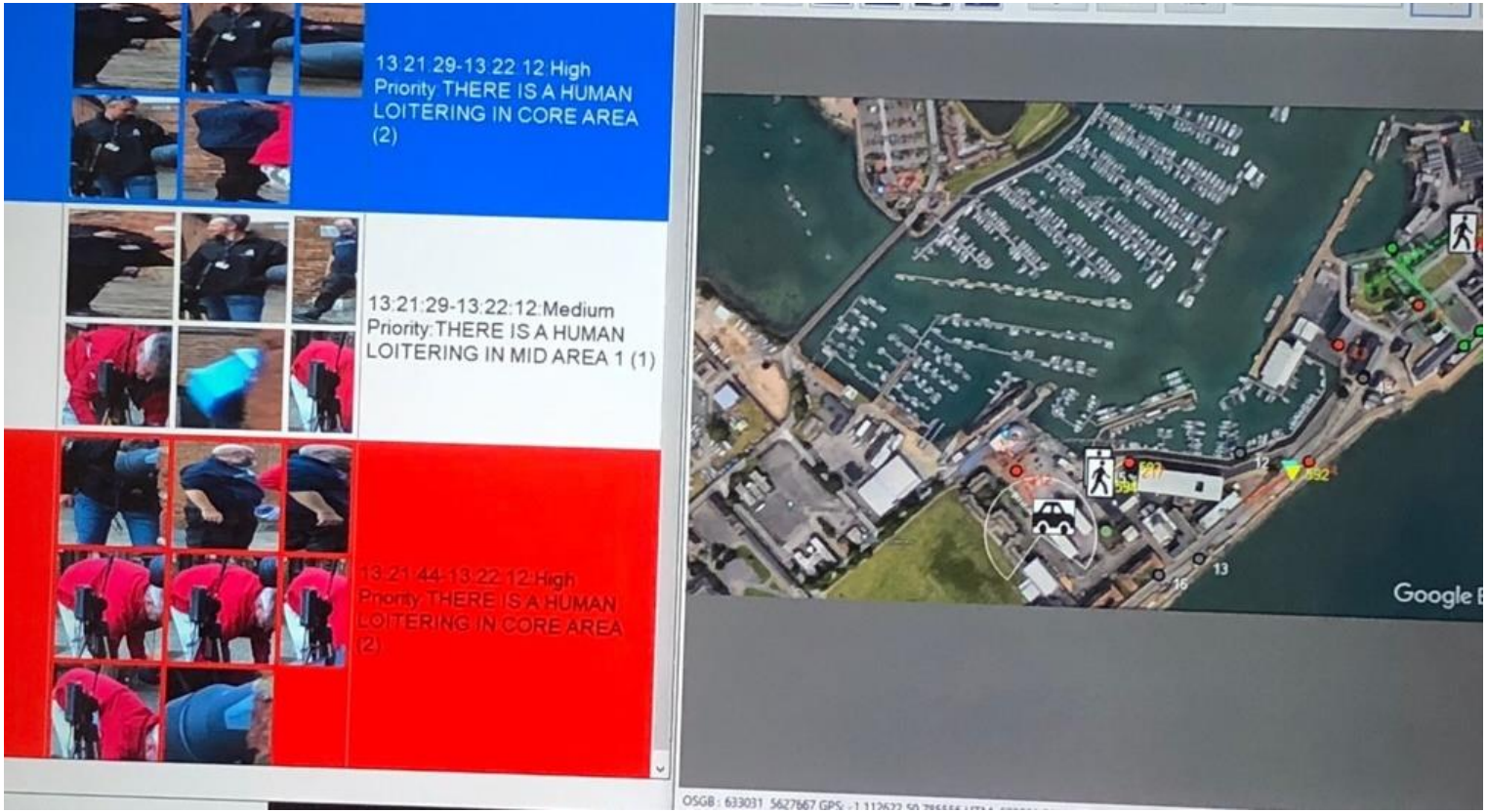
Sensor – Flexnet

The Exensor FLEXNET is a proven, fully integrated UGS solution for perimeter & persistent wide area surveillance. The system consists two Seismic/Acoustic sensors, two Passive Infra-Red (PIR) sensors and one Scout MKIII Camera, connected to the UMRAWin C2 node and the SAPIENT HLDMM through a Mesh Radio Network and a SAPIENT Integration Translator module.

Mobile Sensing

A key concept in SAPIENT is taskable sensors – sensors that can be tasked by the DMM to perform an autonomous mission. To experiment with this, DIET uses three Clearpath Unmanned Ground Vehicles (UGVs) equipped with various sensor technology and the Cubica OMNISCIENT system (which is inherently SAPIENT compatible). This allows exploration of the value of unmanned platforms in tactical ISR missions, enabling troops to avoid enemy fire.

SAPIENT GUI showing alerts, icons and imagery



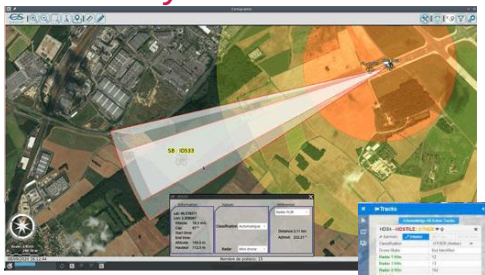
C-UAS Technical Interoperability Exercise

- TIE21 ran from 2nd – 12th Nov 2021.
- The exercise tested technical interoperability standards and solutions between systems used to counter CLASS I UAS
- The goals of the testing were:
  - to identify a set of standards relevant for the NATO C-UAS domain;
  - Implement these standards in a collaborative environment;
  - demonstrate interoperability between C-UAS components and fully integrated systems;
  - evaluate C-UAS technical architectures and identify standardization gaps

Systems

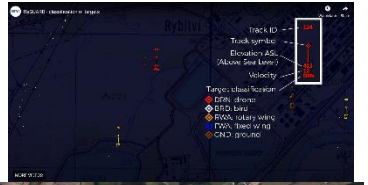
17 x Operational sensing/effector systems

7 x C2 Systems

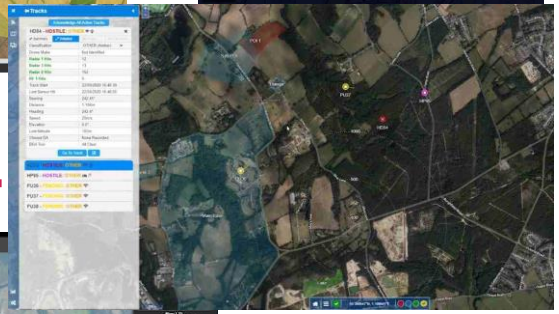


- CS Group - Boreades

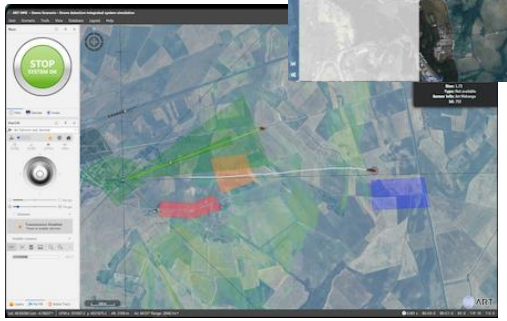
- ReGuard - RETIA



- OSL - FACE



- ELDIS / CSG Aerospace



- Advanced Radar Technologies

SAPIENT Interface Management Panel (SIMP)

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- Exists to put the SAPIENT ICD under formal configuration control
- Collaborating with BSI to progress towards a Publically Accessible Standard (PAS).

Interface Control Document

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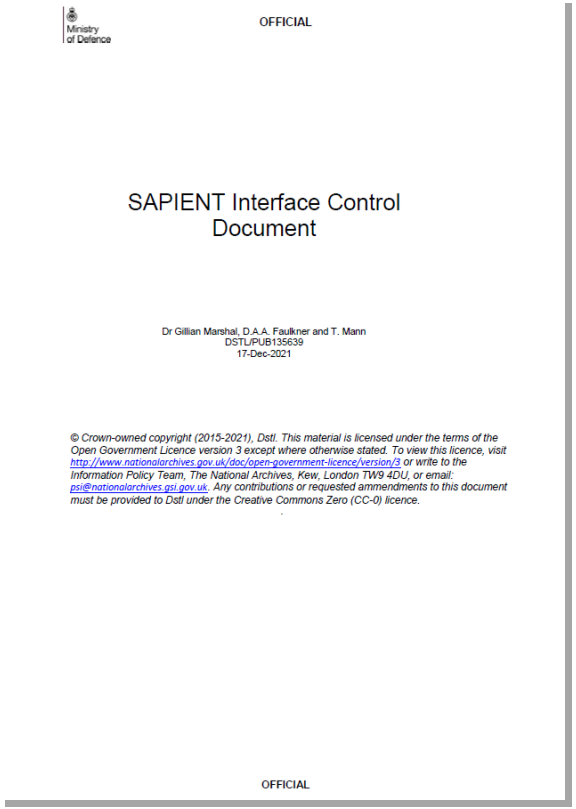
Current version V6.0



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SAPIENT Interface Control Document

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Architecture scaling – decentralised, hierarchical

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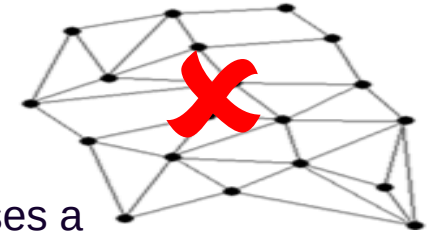
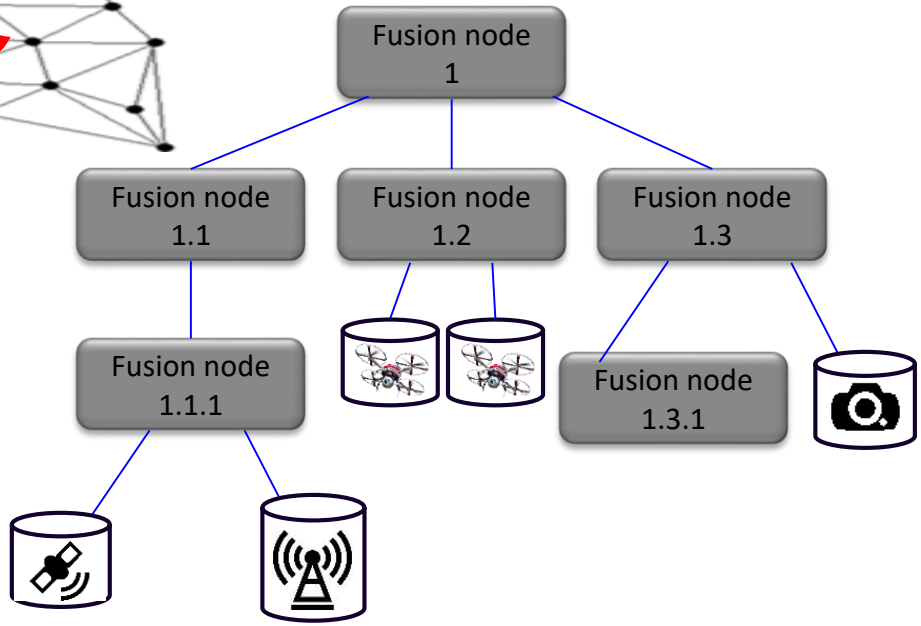
As SAPIENT scales to a decentralised model, it imposes a constraint of a hierarchical topology.

This is to avoid:

- data incest
- Diverging consensus across the network





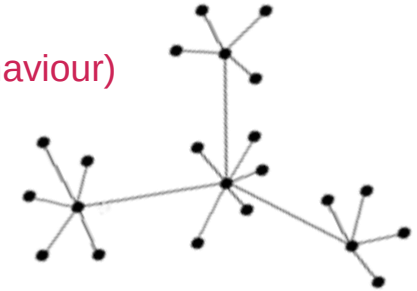
Hierarchical is a special case of decentralised, where the structure is ‘tree-like’ i.e. Acyclic. Formally (graph theory): any two vertices are connected by exactly one path.

Opportunities

Research:

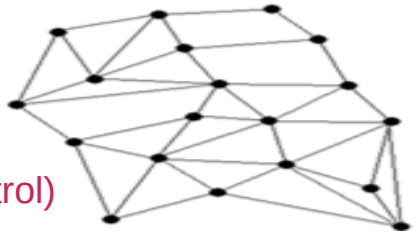
Acyclic topology:

- DMM fusion problem = integrated multi-type fusion (plot, track, class, behaviour)
- Lossless summarisation up-hierarchy
- Optimal sensor management down-hierarchy

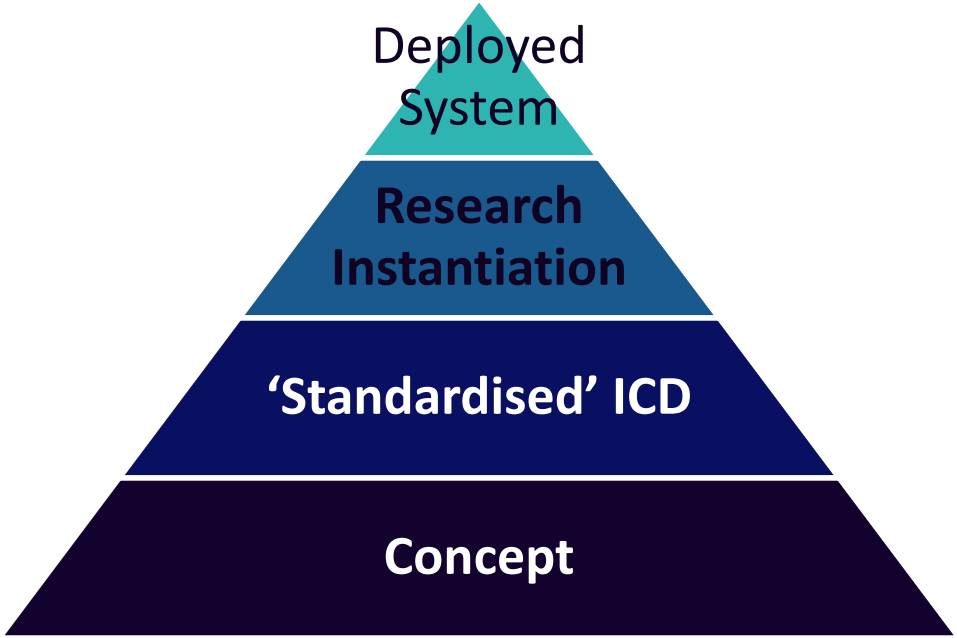


Cyclic topology:

- Mitigation of data incest
- Bandwidth conservative consensus (state and control)



What is SAPIENT?



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