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Operating a multiplicity of remote sensors in contested comms: a requirements analysis

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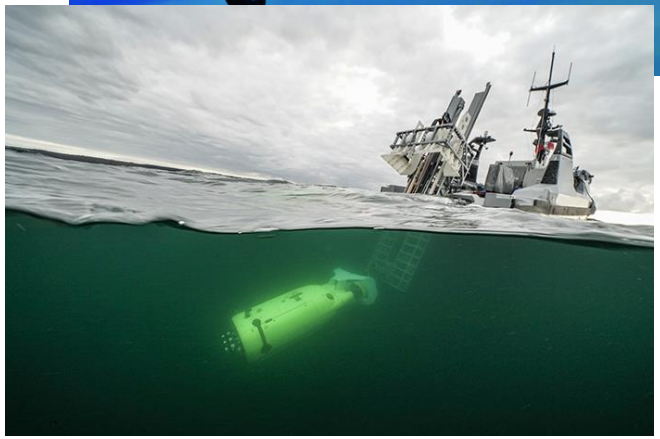
We present a data flow analysis for a system containing multiple remote sensing assets. It identifies a need for certain algorithms and places these in context. An important driver is that communication with the remote assets may not always be available. Other than this, we avoid making choices that limit the solution space. The resulting model is simple, but has held up over the period since it was created, more than ten years ago. I hope the academic community finds it useful.

(some of) Thales' involvement

Mission systems for T31 Frigate

Mission systems for armoured vehicles

Watchkeeper



Maritime Mine Counter-Measures

Thales Autonomy Footprint

● = Major Thales Site

Queens University
Cyber security & human factors research

Advanced Manufacturing & Research Centre

Edinburgh University
Heriot Watt
Learning processes for robotics
Information fusion for situational awareness
Machine learning

National Automotive Innovation Centre

York University
Institute for safe autonomy

West Wales Airport
UAS test centre including segregated airspace

National Digital Exploitation Centre
Including autonomous vehicle cyber security

Complex & Connected Systems Research Partnership

Thales Maritime Autonomy Centre
- Anglo-French MMCM development
- Digital twin demo
- Future Ocean Initiative
- Plymouth Smart Sound
- FAST Cluster

UK Smart Mobility Lab

Larkhill UAS Training School

National Oceanography Centre

Southampton University Trustworthy Autonomous Systems Hub

Digital Aviation Research and Technology Centre (DARTEC)
National Beyond Visual Line of Sight Experimentation Centre

Cranfield University Autonomous Vehicle Research Facility

Thales R&D Centre
Advanced Train Positioning development

Surrey University
Cyber security research

UK Centre for Connected & Autonomous Vehicles

Connected Places Catapult

Docklands Light Railway
- In-service Autonomous Trains
- Obstacle detection development with Transport for London

Watchkeeper deployed to Lydd Airport in support of Home Office with Migrant Boat monitoring

Fusion Centre

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Objective & Motivation

- Military branches expect to make more use of remote assets: UAV / USV / UUV / UGV
- Non-functional requirements: safety, usability, staffing, resilience against jamming…

Tasks

Priorities

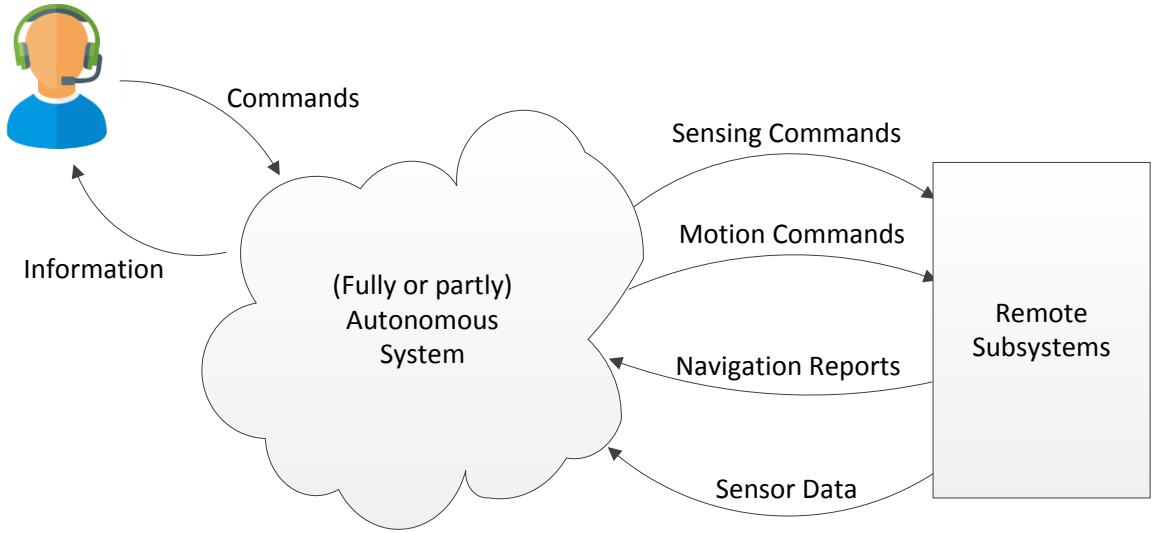
Detections

Classifications

Imagery

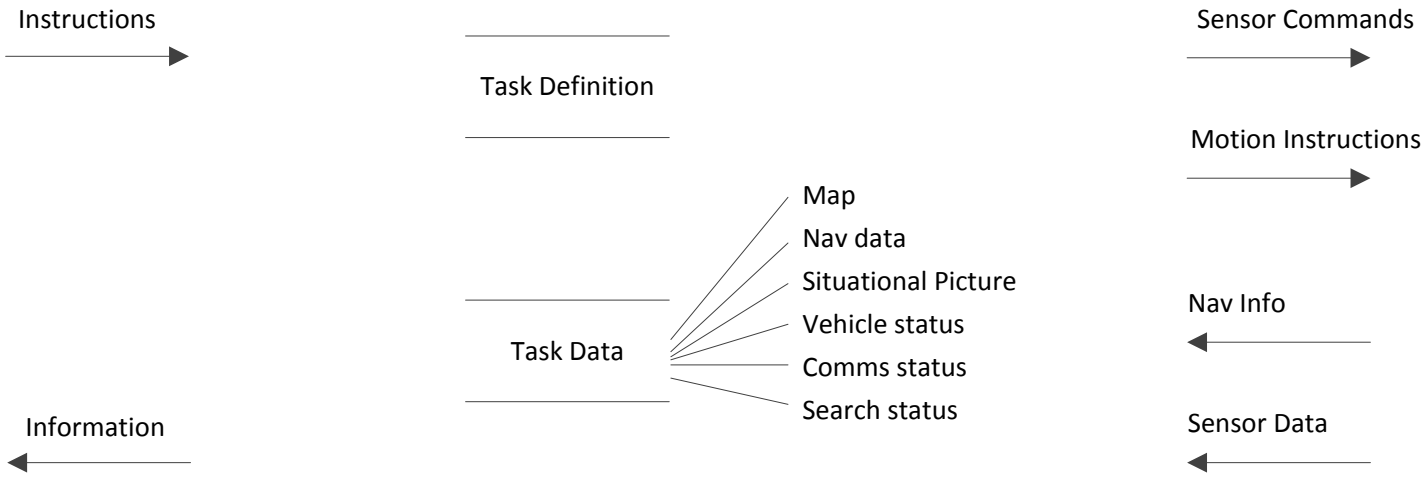
These drive the requirement for autonomy

Context diagram for an intelligent ISR system



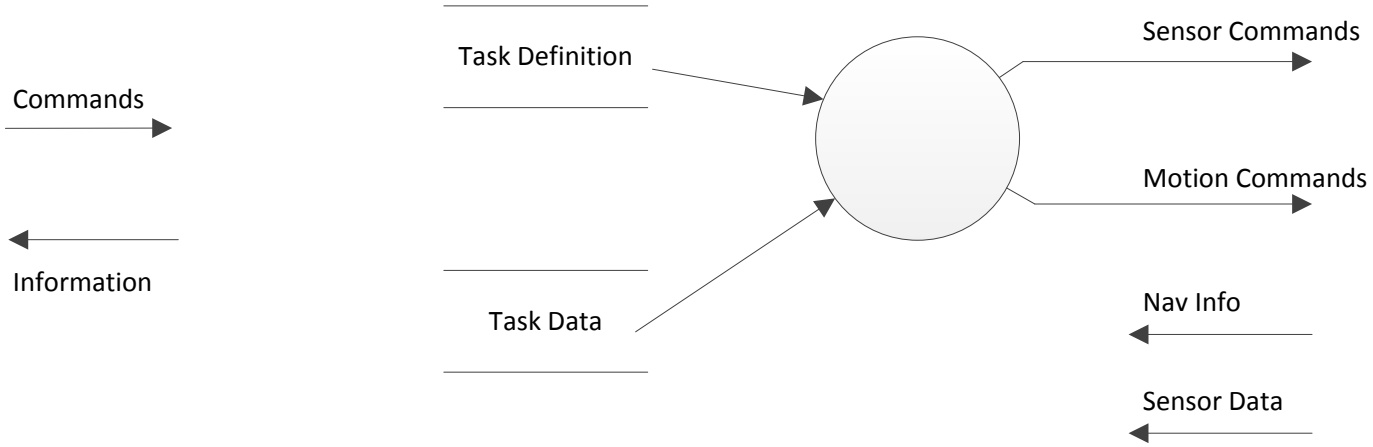
- The intent of this and the following slides is to bring out elements that are necessary, that are not subject to arbitrary technical choice.
- At this stage we exclude consideration of how the intelligence is distributed across platforms, because this is subject to a lot of design choice.

What data is needed inside an autonomous ISR system?



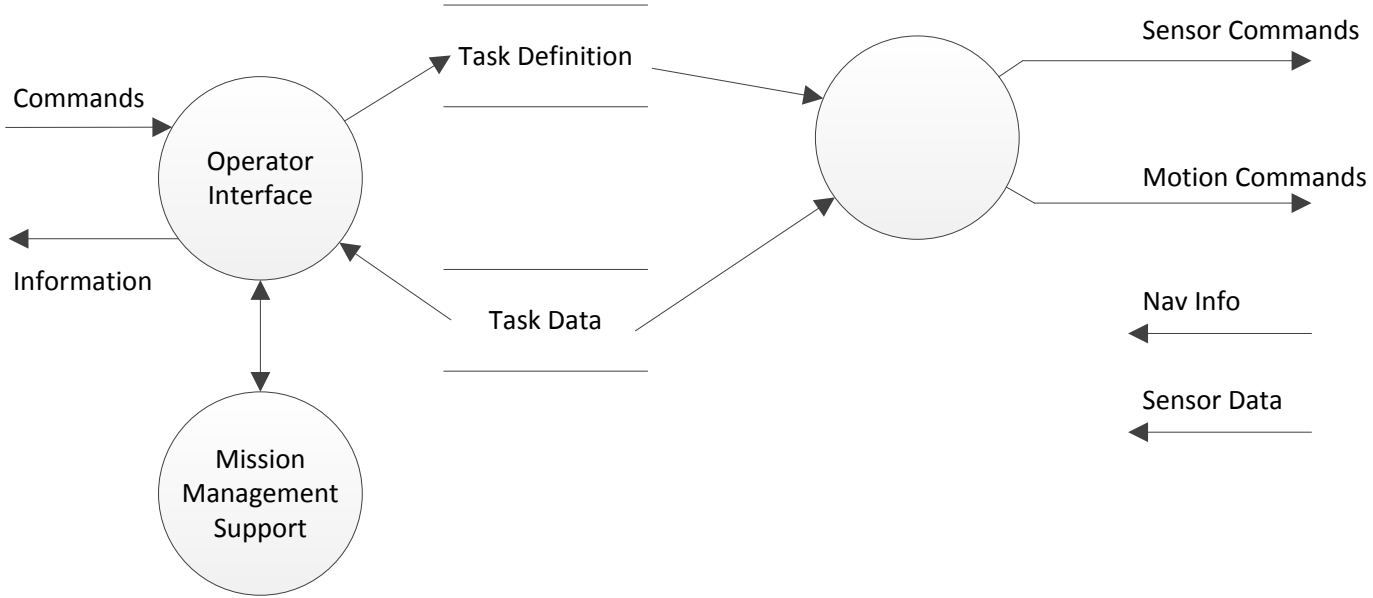
- The system must have a record of what the task is ('Task Definition'), and it must have enough information about the task to perform it ('Task Data')
- If we want the system to continue to perform a function when communication is unavailable, then the task data needs to be located on the remote system.

Join them up!



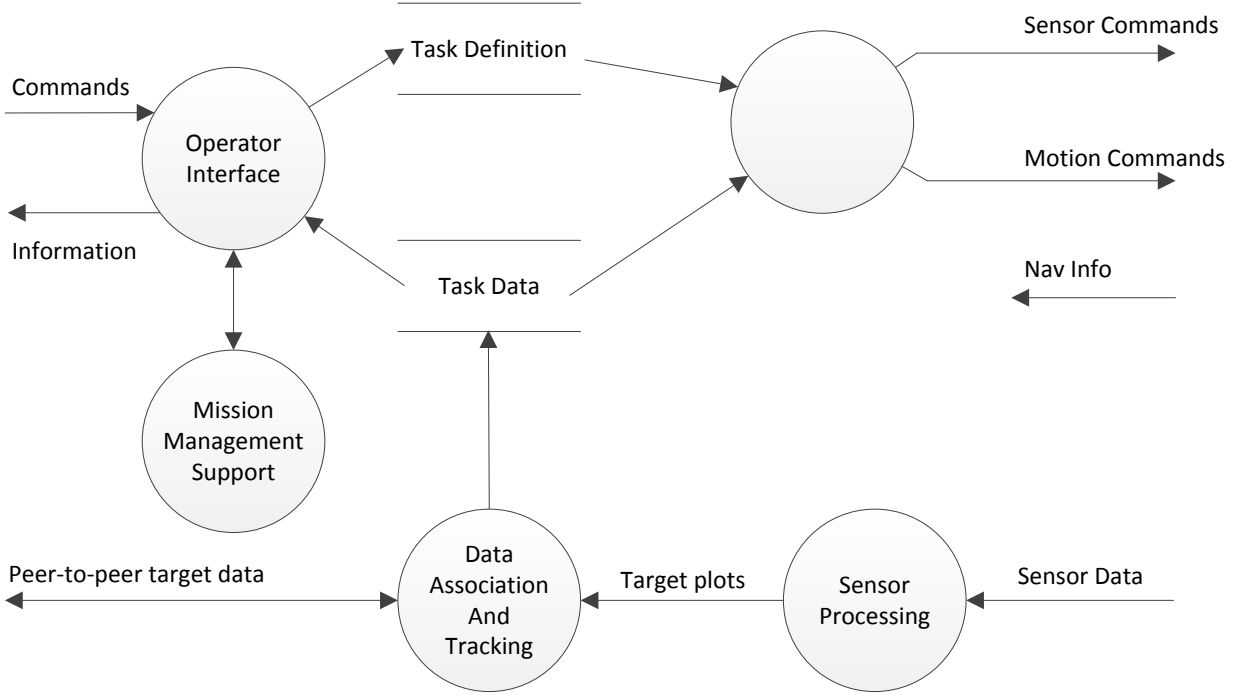
- The output commands must be computed from the ‘Task Definition’ and ‘Task Data’.
- A tautology, having defined the Task Data as ‘that needed to perform the task’.

The operator interface



- Algorithms to support mission management can be shown as an adjunct of the Operator Interface. These may be granted more or less freedom to act on the operator's behalf.
- The operator interface and any supporting algorithms may be distributed between the control station and the remote vehicles

Sensor data

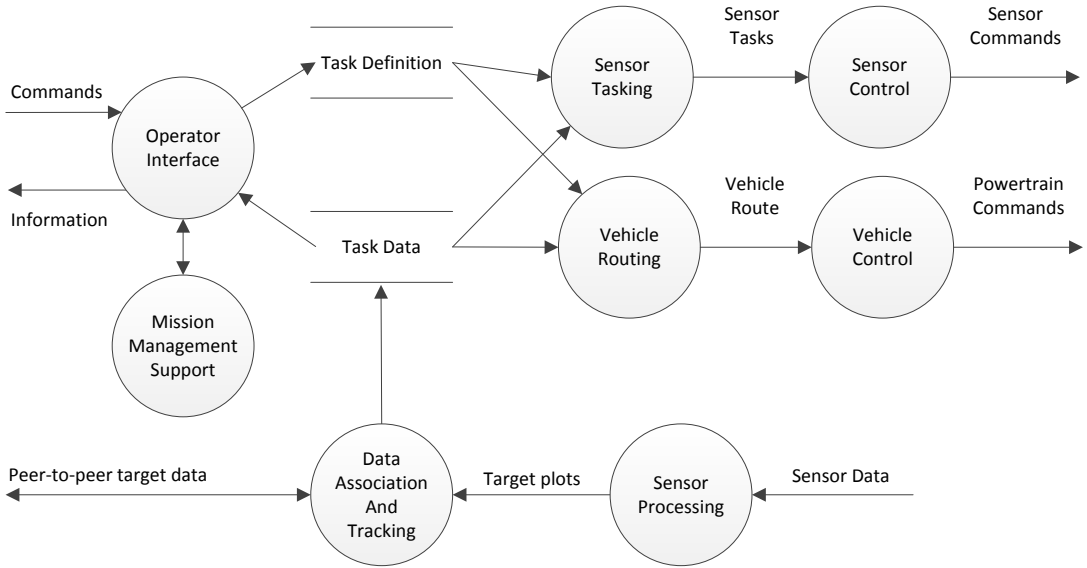


- We need algorithms for target detection, classification, tracking.
- Tracking may be distributed, e.g. using peer-to-peer communication

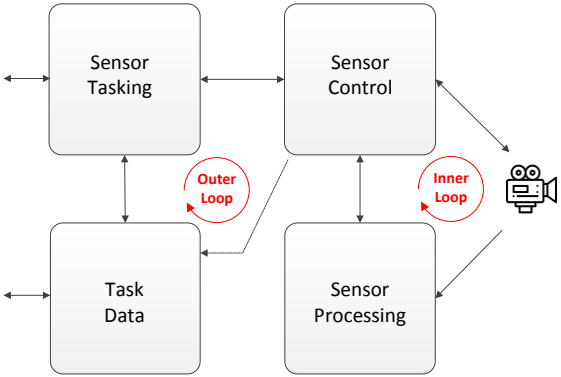
Filling in the blank process, assuming a UAV with a PTZ camera

- We assume 'Sensor Tasking' and 'Vehicle Routing' don't need to share internal data
- 'Sensor Tasking' may be collaborative (with peer-to-peer communication not shown)

Data flows



Control-loop perspective



And looking at the set of processes we have…

- **Data association and tracking**
- **Sensor tasking**

Especially relevant for this community

- Sensor processing, Navigation, Mission Management Support Algorithms, Vehicle routing

In several cases, we can satisfy requirements – with effort – using centralised architectures

A challenge is to migrate to distributed ones to provide better resilience against loss of comms

This involves trade-offs: the performance may not be as good as a fully centralised algorithm. We welcome research in these areas!

- Thales is active in several of these areas - my paper on distributed sensor tasking: https://doi.org/10.1117/12.2534290

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