HEXAGON

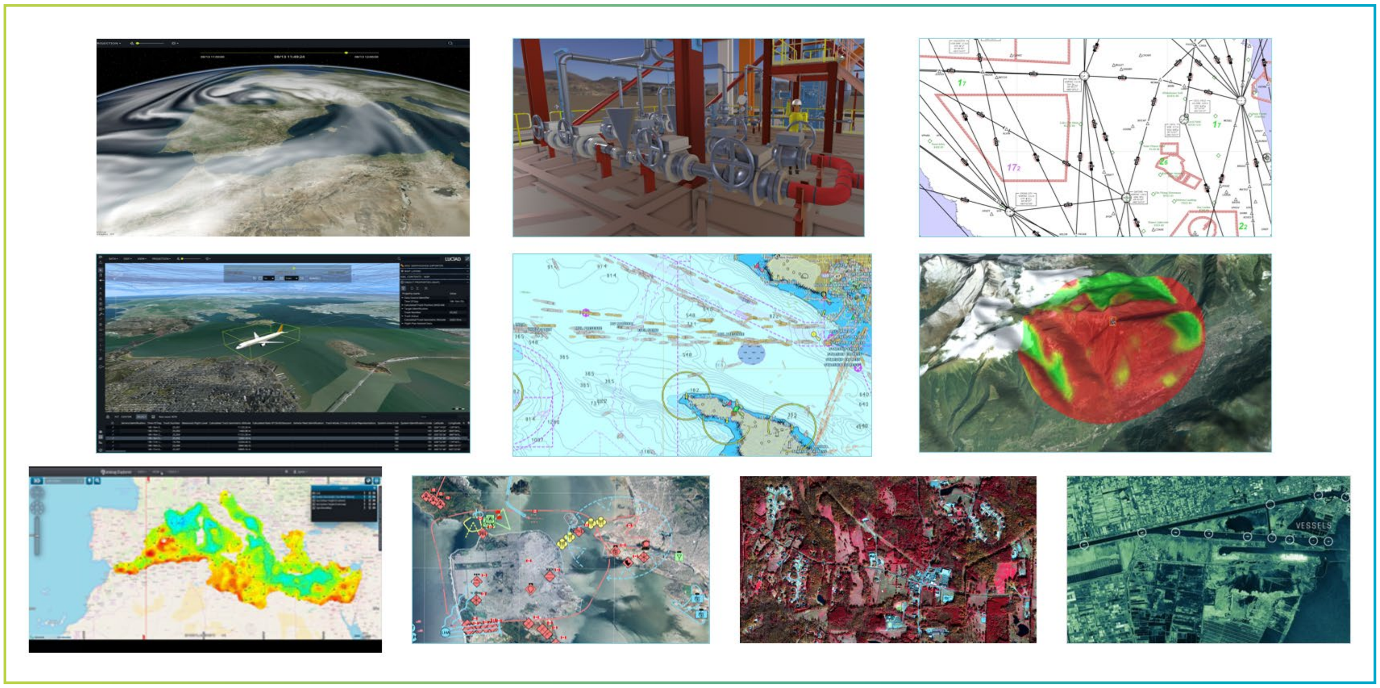
White paper

Automating geographic content

Underpinning IAMD decisions with AI and data fusion

A modern integrated air and missile defence (IAMD) system is a collection of subsystems made up of sensors, controllers and effectors. NATO said its IAMD "provides highly responsive, robust, time-critical and persistent capabilities in order to achieve a desired level of control of the air." Interoperability of subsystems and ease of data exploitation for the IAMD commander directly affects the IAMD's response speed.

This paper will look at geographic data and software and their uses within IAMD. Examples from recent CUAS exercises, updates on what's possible with commercial off-the-shelf software and customer experience in various air defence systems will be examined.



Examples of data types used in IAMD – including weather, flight paths, terrain, earth observation and tactical movements

The use of geographic data and GIS within IAMD is well-known; however, data and digital transformation tools for IAMD are relatively underused. Leveraging advances in geographic data automation at various stages of receipt, analysis, exploitation and dissemination can bolster IAMD responsiveness.

Data feeds into IAMD can include radar tracks, acoustic sensors, camera sensors (optical and thermal), terrain models, weather data and aeronautical charts. These data feeds can be analysed via artificial intelligence (AI) or machine learning (ML), which generate outputs and feed into IAMD. To allow the IAMD to fuse together differing data feeds, dynamic and static data, there needs to be interoperability of systems, usually easiest achieved by early adoption of industry standards. Whether it is using defence communication standards, such as Link 16, or geographic data standards such as those set by Open Geospatial Consortium (OGC), system manufacturers need to use standards to allow interoperable systems architecture and ease of technology upgrades.

Cataloguing data

An important first step is cataloguing sensor feeds and any physical data. This stage involves validating data in terms of its relevance to the area of operation for the IAMD and the quality of data, such as ground resolution of terrain. Presuming the data is accepted, it should then be catalogued along with any metadata such as its source, date of capture, resolution and other properties. This metadata can act as the basis for users and automated processes to discover the data later and use it in IAMD. The metadata will assure users of the authenticity of the data and give assurance of its use.

Two more important points for cataloguing data are to give a single place for users to query data and enhanced access control of the data. Through a browser-based portal or via a RESTful API, users and systems have one entry point to search for and discover data. Since catalogues can be federated, this one catalogue search can query across other catalogues, reducing data and information silos. This helps promote the “need to share” concept in a controlled and secure manner.

Conversely, rigid access control for users and systems is needed to enhance data security. This can determine which datasets users can discover and view, and if they can discover data from different geographic areas (e.g., not revealing all high-resolution data of sensitive sites to allies). IAMD users and systems need to have knowledge of what data is available and if it’s suitable for use. Without this, the value of the data is lost, and the decisions made may lack crucial information. ERDAS APOLLO, as an end user product, and LuciadFusion, as an SDK for integration into systems, both offer cataloguing and data provision.

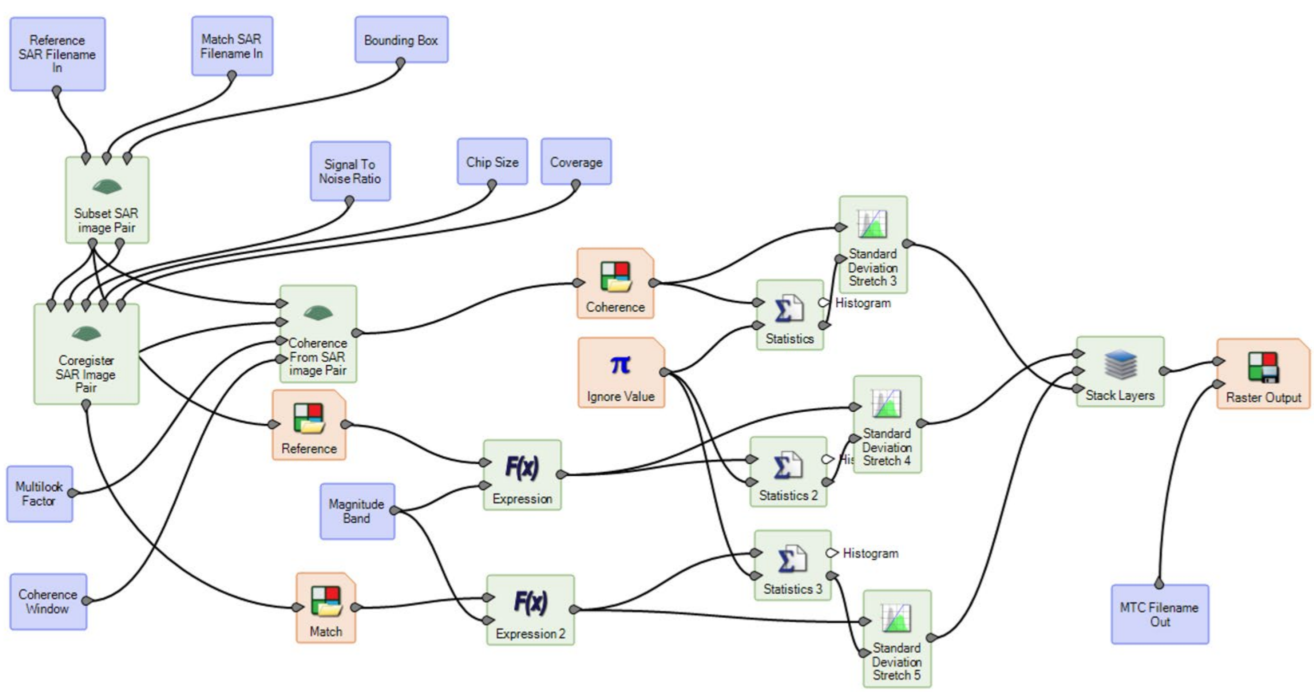
Analysing data

Once a user or system has discovered relevant data, they usually want to analyse that data in some way. This could include using terrain data to determine a good location for a radar system or using optical imagery to determine the best route for vehicles to that location. Information can be delivered to users via automatic analysis of data, using ML, AI and processing workflows. When data is processed and analysed, IAMD users can extract valuable information to gain knowledge.

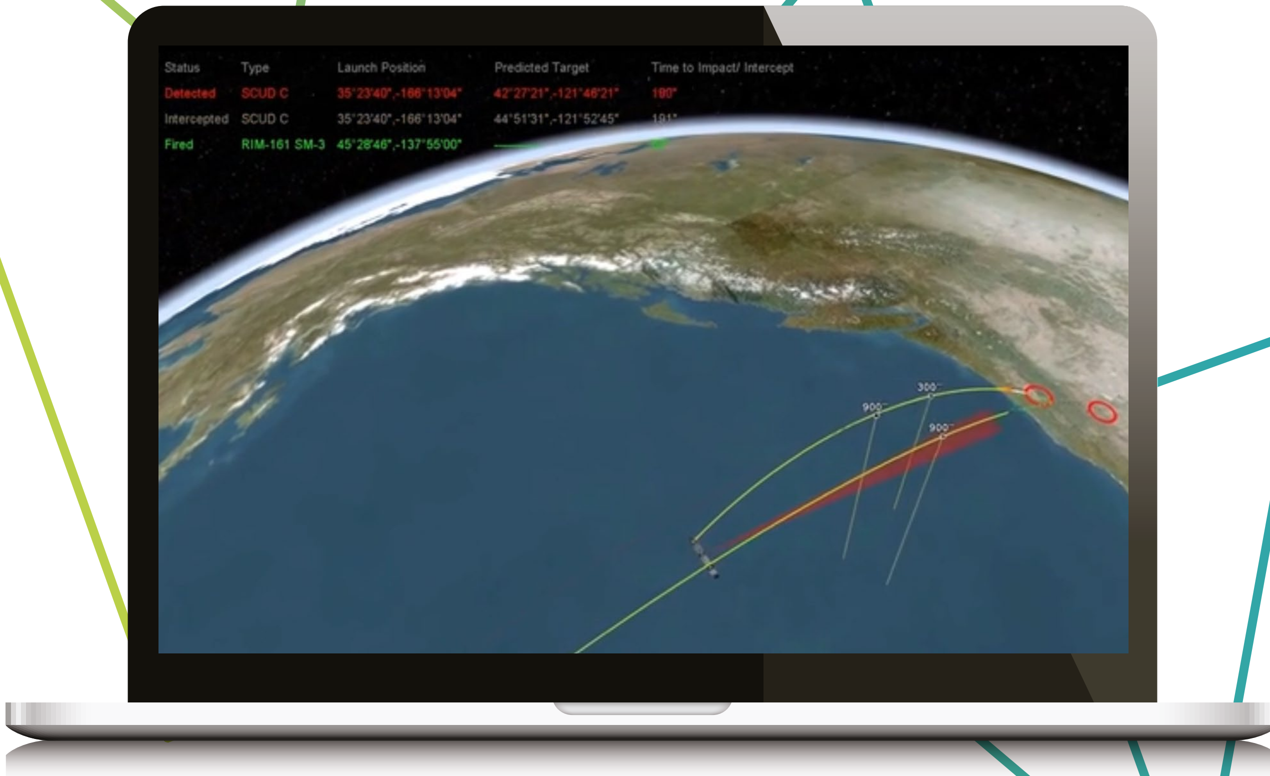
Processing and analysing geographic data require certain skills and background knowledge of the data, software and desired end result. While geographic technicians may be deployed with IAMD to perform this analysis, having the analysis captured as a digital data workflow means any user or system can run the analysis. The data workflow can be created at headquarters and shared among users either as a physical file or as a web API service. End users do not need to know how to perform the analysis; they simply need to know which relevant data workflow to run and analyse the latest data available to them. The use of data workflows increases analysis capacity and reduces variability and inaccuracies introduced by individual users running analysis by hand.

Data can be analysed in real time with real-time data feeds, such as tracking UAVs, and real-time interaction between users and data visualisation. The former can be as simple as visually highlighting the airspaces in which a UAV is active or performing spatial calculations on trajectories and intercepts using bounding boxes. The latter can be a calculated line of sight drawn over terrain data as the user moves around the observer position on screen. This is a quick way to check a route for blind spots. Spatial Modeler, which is delivered as a graphical editor and an SDK, is used to create these data workflows.

Modern IAMD can incorporate simulation and prediction routines and algorithms to help commanders validate decisions and alternatives more quickly. In a digital data environment, running “what if” analyses are also possible, both in a training environment and when operational. This can also feed back lessons learned to aid continuous improvement of processes and procedures for future deployments.



An example data workflow, in a graphical editor



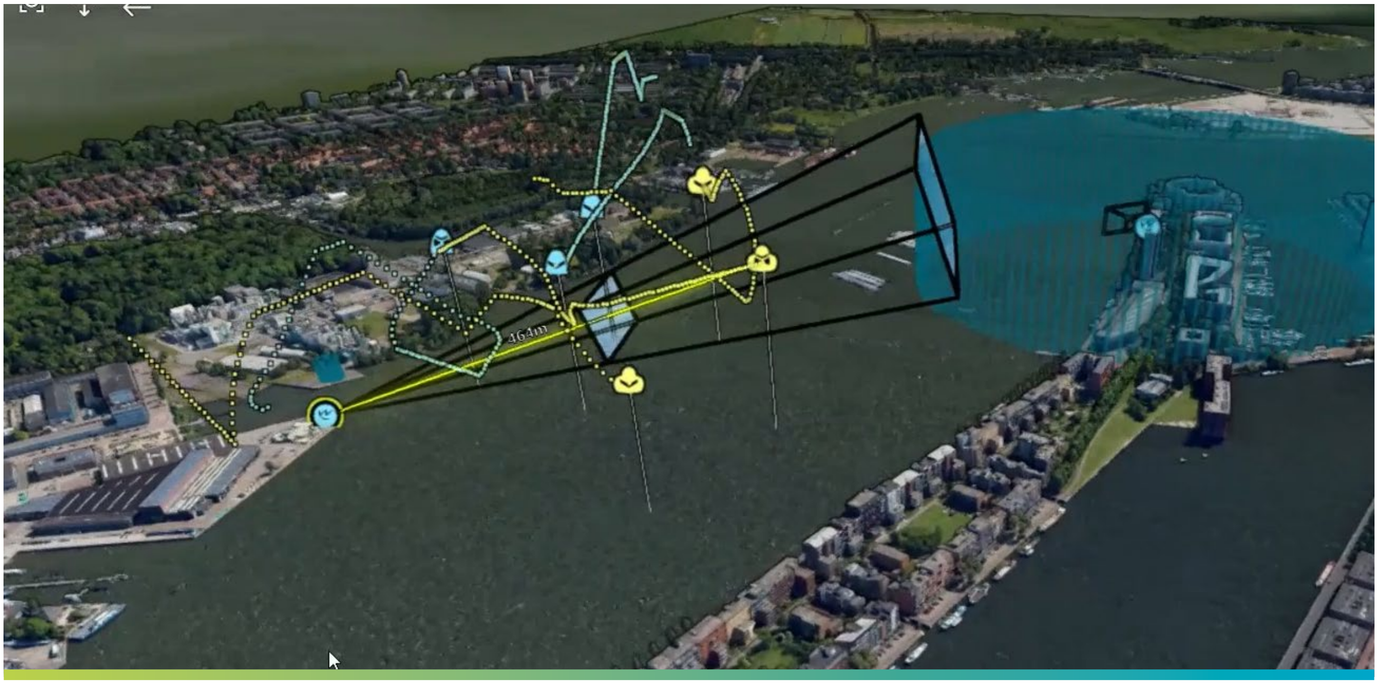
Visualisation of missile trajectory and interception

Visualising data

Most of the data and derived information will eventually need to be delivered to users and other systems – users need the correct information in the correct format at the time of relevance. Through automation of dissemination and ease of retrieval, decision-making is faster because users and systems don't have to search for information. The delivery medium can be visualised on a screen, showing a 3D view of the terrain, sites of interest, airspaces above them and the predicted or tracked locations of missiles.

Alternatively, the delivery medium can be a simple notification to users via email of new, relevant data in an area of interest, which allows them to access the data and view or analyse it as needed. If the data and information are delivered to another system, even a subsystem within the IAMD, it will be delivered as a standard data format or web API service. These are publicly documented and used by multiple vendors to allow data sharing. There can be an authorisation façade on the services so only intended users can access the data.

The visualisation of information and data can help users interpret and understand a situation quickly, whereas a 3D view of real-time data and analytics depicts thousands of sentences. And by utilising advanced browser technology, the IAMD C2 delivers timely information to commanders. The view can be made up of real-time tracks, predicted tracks, weather information, background geographic data and ad-hoc analysis results. Automated highlighting of certain data or objects in the view helps users discern relevant information. For instance, airspaces can be represented as volumes (e.g., 3D shapes) in the visualisation, and each airspace highlighted as air traffic (e.g., drones, missiles, etc.) passes through it. This gives operators easy to see and easy to interpret situational awareness. The SDK LuciadCPillar is one product for C++/C# developers that supports IAMD development.



Example of multiple sensor feeds, including AI classified drone tracks, radar responses and video feeds over a demonstration area

Gaining trust in AI and ML

AI and ML are used throughout the various processes described above, whether to identify suspect UAVs from a video feed or locate suitable anti-missile battery locations. As AI grows in adoption and is more widely utilised, users will begin to gain trust in it as well.

However, IAMD systems still have human-in-the-loop (HITL) processes to decide when to deploy an effector, whether lethal or not. To add confidence in AI, data fusion can be used in outputs of various sources. Sensors can have their own AI onboard and can, for example, classify objects in a video feed such as birds, UAVs or planes.

If the AI is processed on the edge (e.g., on the sensing device), alerts, such as for a suspect UAV, can be transmitted back to the IAMD C2 instead of all raw data. Data fusion will then use AI to ascertain if the alerts reported by the sensors are of the same rogue UAV or separate ones. At the C2, the operator has a lower cognitive burden since only significant alerts are displayed. Through C2-based AI, and in correlation with data fusion, alerts from different sensors can be confirmed against third-party sensors including other nations' assets.

In closing

As with many systems of systems, the output of an IAMD can be greater than the sum of its parts. Using interoperable data formats, communication services and automation of data receipt, analysis and distribution, the modern IAMD can reduce reaction and decision times for commanders.

Hexagon has proven its product and technical expertise during NATO interoperability exercises. Discover how Hexagon's solutions can help defence organisations and systems providers integrate, visualise and analyse mission-critical data in dynamic common operational pictures that support better situational awareness and faster, more informed decision-making.

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