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Multi-Domain Integration

Whitepaper

Contents

Courtesy of L3 Oceanserver

Introduction

To achieve operational, tactical and strategic effects, navies around the world are employing an ever-expanding range of artificial intelligence and unmanned systems in the air, space, underwater, on the surface, over land and increasingly in cyber domains.

Initially unmanned maritime systems (UMS) have been employed individually from a centralised operating base on land, at sea, or from an airborne platform. As missions grow in scale, so have larger squads of multi-domain UMS been employed to deliver greater effect and improve mission timelines.

As the navies use of UMS increases, so has their operational need to integrate UMS across multiple domains, integrate UMS sensors into exisiting naval warfighting units, and cooperate multinationally.

The idea is that by domains acting together on issues, it will create a force multiplier effect, with outcomes achieved faster, more effectively, and succesfully than relying on one or two domains.

This whitepaper is based on our experience developing a Multi-Domain Controller Suite (MDCS) that has been used on a number of live UK and International events including; Autonomous Warrior 2018, REP(MUS) 2019, and Advanced Autonomous Force 2.0.

> *During the events, the MDCS succesfully integrated and tasked UMS across the air, surface, subsurface, and ground domains from different vendors and nations working together.*

Problem 1: Gluttony of ground control stations

As the range of UMS vehicles types have grown in variety and capability, from an ever-increasing number of vendors, so has the Navies use of them to deliver tactical and strategic effects. Navies face a range of challenges when integrating multiple UMS across different domains and from different vendors, including:

Incompatible ground control stations

UMS systems have traditionally come with a dedicated ground control station (GCS) to control one or more of their vehicles. One GCS operator is required for each vehicle type, increasing the total number of operators that are needed and consuming valuable real estate in the CIC or operations room. Often the UMS utilises vendor proprietary interfaces, preventing UMS from different vendors working together. Stove-pipe solutions such as these can result in vendor lock-in, constraining the Navies ability to upgrade, replace, or add new capabilities.

Mythical unmanned systems

Far from being 'unmanned' some UMS systems actually increase the burden on man power to operate and maintain them. This adds significant pressure on DLODs for Training, Support and Maintenance, and increases skills fade as operators are expected to switch between driving GCS from different vendors.

Pick and mix best-of-breed capabilities

Many Navies would like to pick and mix the best of breed capabilities from different vendors, to satisfy their mission requirements and available budget. Stove pipe solutions make this very difficult and potentially very expensive to realise, discouraging many Navies from even trying.

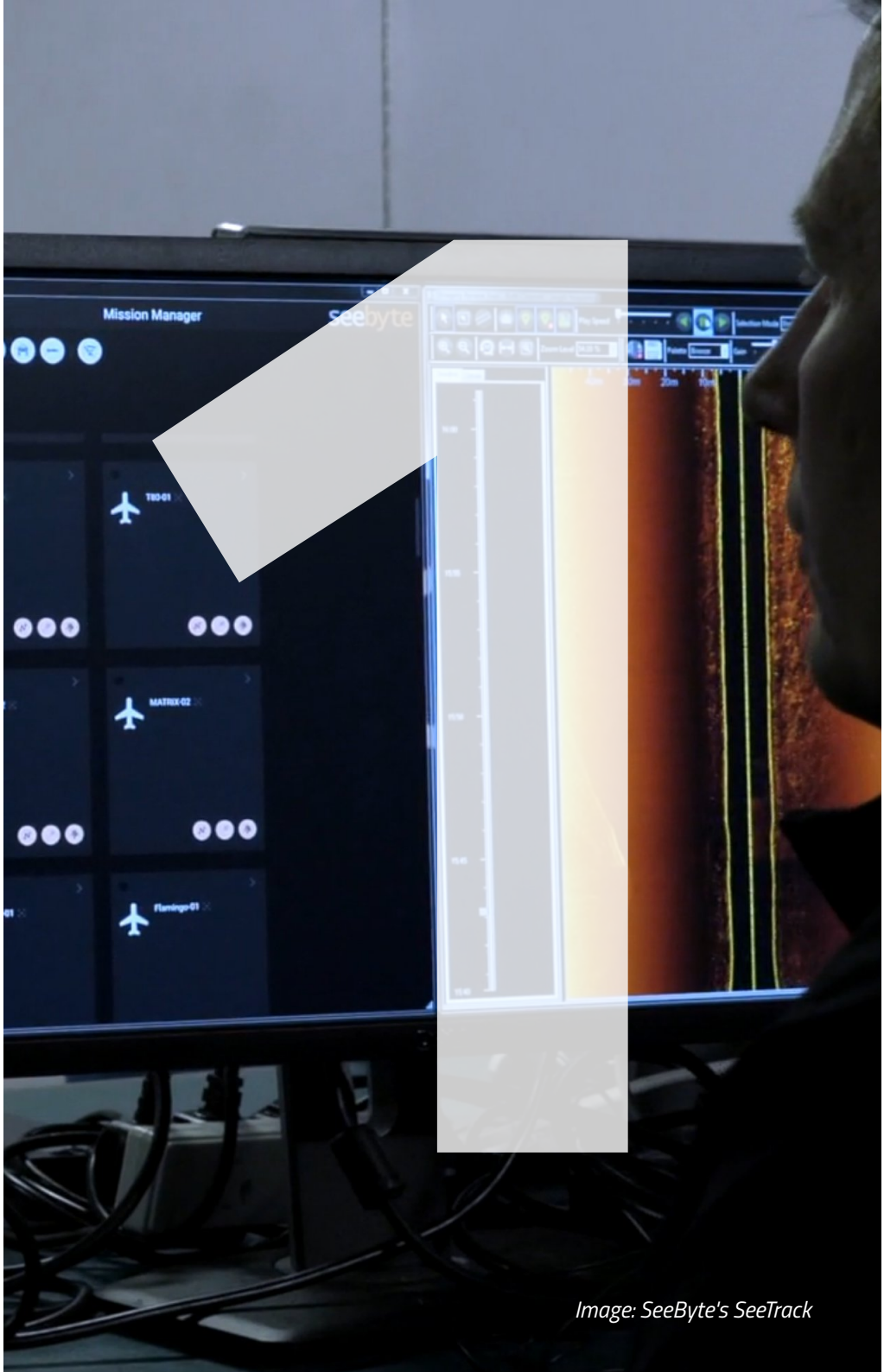


Image: SeeByte's SeeTrack

Image: Ben Shread

Problem 2: Data Islands

As the utility of UMS has increased, so has the Navies need to seamlessly integrate UMS with one another, into the combat systems warfighting functions, and to do so without needing more staff in the CIC/Operations room. Challenges include:

Multi-domain missions

With standalone UMS the operator needs to prepare mission plans for each domain vehicle individually, manually pulling together an integrated mission plan from the individual component plans. Where multiple UMS work together as a squad to perform a common goal, this requires the operator to manually breakdown the task and produce individual component plans for each asset. Manual deconfliction of component plans and coordination of UMS assets can prove to be very difficult to achieve and error prone. As soon as mission parameters change or a vehicle has a fault, the mission plan is broken and needs to be updated and redistributed to the UMS.

Operator overload

Operator workload increases as the number of UMS assets increases, coupled with the level of mission autonomy within the system. A low level of autonomy (e.g. waypoints) limits the operator to controlling perhaps 3 to 5 UMS assets, whereas a high level of mission autonomy (Goal Based) permits 5x to 10x that number of assets.

Combat system integration

UMS, and more so UMS squads, augment the capabilities of the Navies ships and submarines, enabling them to capture higher resolution imagery, deliver effects, and penetrate deeper into the threat area. Navies need to integrate the UMS into the existing war fighting functions, with the ability for the command team to task UMS Squads during the mission as they would direct an electro-optic camera, for example.

Multi-domain use case

A Multi-Domain Control Station (MDCS) has been used in a number of live events, including Autonomous Warrior 2018, REP(MUS) 2019, Autonomous Advanced Force 2.0 and many others. All of these exercises integrated and tasked multiple UMS across the air, surface, subsurface and ground domains from different nations working together.

Typical scenario

A high value asset is operating in a contested area to provide humanitarian relief in the region. A UAV deploys sea acoustic sensors in the mission threat area, and loiters in the area to provide communications rebroadcast and surface overwatch.

A USV squad (3x) performs a Patrol task up-threat. A UUV squad (3x) are deployed to perform an underwater search.

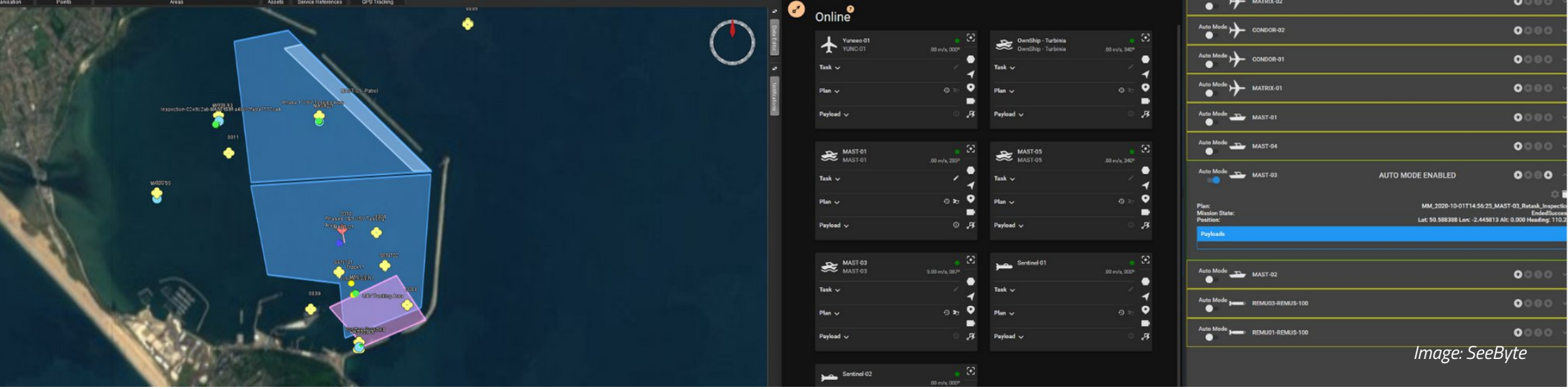
During the mission one USV is dynamically tasked to intercept and shadow a FIAC and prevent its progress toward the HVA, the UAV adaptively manoeuvres to provide overwatch of the FIAC incursion. All of the UMS are controlled by the MDCS operator. UMS sensor imagery is relayed to the MDCS, the combat system warfare functions, and MDCS picture is shared with other units via LINK16.

Trials use case

The MDCS was the common interface for mission planning and control for the UMS network, and maintains the situational picture that was shared and integrated with the local RMP, and distributed over LINK16 to allied forces.

The MDCS enabled rapid 3rd party integration of numerous UMS vehicles and payloads from different nations and multiple UMS vendors.

A Synthetic Environment as part of the MDCS was used to rehearse and validate the mission plans prior to live exercise. The SE also augmented live exercises by simulating red and blue forces.



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Solution 1: Take control of the interfaces

Modern Navies demand open, flexible, adaptable solutions enabling them to plug-and-play new capabilities, upgrade or replace existing ones, without being locked into the original equipment manufacturers or the cost of requalifying monolithic solutions.

Insist on genuinely open systems

Open systems architecture gives customers the confidence that they have the ability to upgrade, replace, or add any component of the hardware or software. Customers and 3rd party companies can readily integrate the MDCS and UMS within their Combat Systems, and other warfighting applications.

There are three recommended approaches that offer equal value to the customer:

1. NATO/Navy Owned Open Standards

Customer developed standards are highly valuable when they are actively supported and maintained with the necessary tools and documentation.

2. Commercially Managed Open Standards

This is how the internet revolution has worked. Vendors freely publish open interfaces for 3rd parties to use, supported by tools and documentation.

3. COTS Open Standards

With so many similar standards too choose from, it is still necessary to choose carefully and publish how the standards are used for 3rd party compatibility.

Seek out solution-agnostic partners

Whether customers have, or do not have, the in-house expertise to develop and manage an MDCS architecture, it is critically important they choose partner companies that are solution agnostic and work with a wide range of UMS and Payload vendors. Ideally working with partners that do not manufacture competing UMS systems or payloads.

Solution 2: Prioritise interoperability

Adopting an MDCS solution offers Navies a new way of integrating data and information sources, and providing mission planning and control for any number of vendor UMS systems. Choosing an open, common framework, that is vendor agnostic gives the end customer the confidence that their systems are interoperable and fully exploit the 'data lake' of UMS information within the combat systems war fighting functions.

Let MDCS do the heavy lifting and tedious jobs

The MDCS is a toolbox of capabilities enabling command teams to focus on the high value mission at-hand, whilst the mission planning and decision tools work under the hood performing the intensive and tedious jobs:

Mission planning and control

Taking the high-level mission goals defined by the operator, the autonomous mission planners breakdown the mission into discrete objectives and tasks to be accomplished. They analyse alternative actions to optimise the integrated mission plan and produce the individual component plans based on the capabilities and resources of each UMS. During the mission the component plans are updated automatically, or on operator instruction, to adapt to environmental change, threats and UMS failures.

Decision support

During mission execution, the autonomous decision aids (ADAs) monitor the mission evolution, alerting the MDCS operator to any emergent and anomalous events, offering a course of action and alternatives to support command decision making, automatically updating the integrated mission plans accordingly.

Mission-level autonomy

Even simple missions can benefit from having mission-level autonomy controlling squads of UMS as a coherent unit to accomplish a common mission goal. The benefits increase when squads of multi-domain UMS collaborate together as a single unit. UMS Squads are provided by mission-level autonomy, which either reside inside the MDCS mission planning and control chain, to direct the individual UMS via component plans such that they operate as a single squad; or the same autonomy can be embedded inside the UMS themselves.

At the C2 level the autonomy has the overall mission situational picture, but trades off communications bandwidth and increases latency, to the embedded case which has zero latency control of the UMS based on a local picture formed by it sensors. The combination of both being the ultimate for MDCS operation.

Invest once, use everywhere

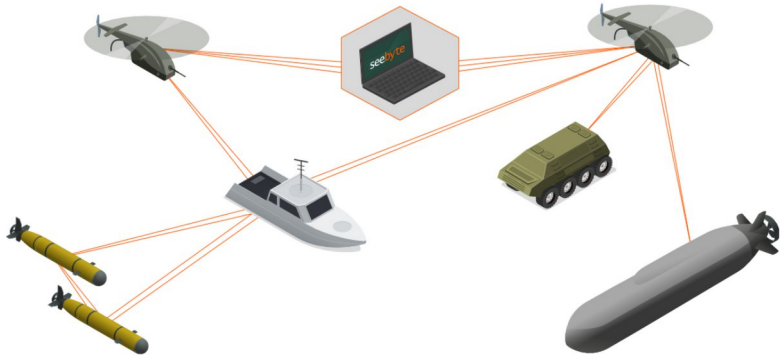
Navies have struggled to train and support the different capabilities and idiosyncrasies between different UMS vendors systems, or have become reliant on a feature from a single vendor that is not transferable to another UMS. This trend is set to worsens as manufacturers add more advanced autonomy features. Building new behaviours and functions in the MDCS exploitable across all UMS domains and all UMS Vendors. The different nuances and idiosyncrasies of each UMS vehicle is managed by the MDCS, providing the Navy command teams with a single common way of working, that fully supports all defence lines of development (DLODs).

> *The MDCS toolkit provides the customer with the opportunity to invest once and use everywhere.*

Conclusion

Adversaries unhindered by doctrine, ethics, or international norms, are willing to employ increasingly integrated threats of different magnitudes and nature to compete just below the threshold of conflict. Navies rely on the tactical-level commanders to think, assess, and employ all domains when necessary to open the window of advantage, and succeed and win in modern congested and contested environments.

The MDCS provides the solution for command teams to see the opportunities for all domains to be integrated, to converge capabilities, and leverage the benefits of each domain in their tactical space. The MDCS toolkit turns everything on its head. Focussing on open vendor agnostic solutions, interoperability, and data sharing:



Genuinely open systems

Open system architecture gives customers the confidence that they have the ability to upgrade, replace, or add any component of the hardware or software.

Vendor agnostic partners

Whether customers develop their own MDCS architecture, or acquire one, it is critically important they choose partner companies that are solution agnostic and work with a wide range of UMS and Payload vendors.

Mission-level autonomy

Even simple missions benefit from mission-level autonomy, controlling squads of UMS as a coherent unit to accomplish a common goal. Benefits increase when squads of multi-domain UMS collaborate as a single unit.

Focus on high value

The MDCS is a toolbox of capabilities enabling command teams to focus on the high value mission at-hand whilst the toolbox performs the intensive and tedious jobs.

Invest once, use everywhere

The MDCS toolkit provides the customer with the opportunity to invest once and use everywhere. Building new behaviours and functions in the MDCS exploitable across all UMS domains and all UMS Vendors.