Intelligent autonomous control systems for surface and sub-surface vessels

Nautomate®: Intelligent autonomous control system

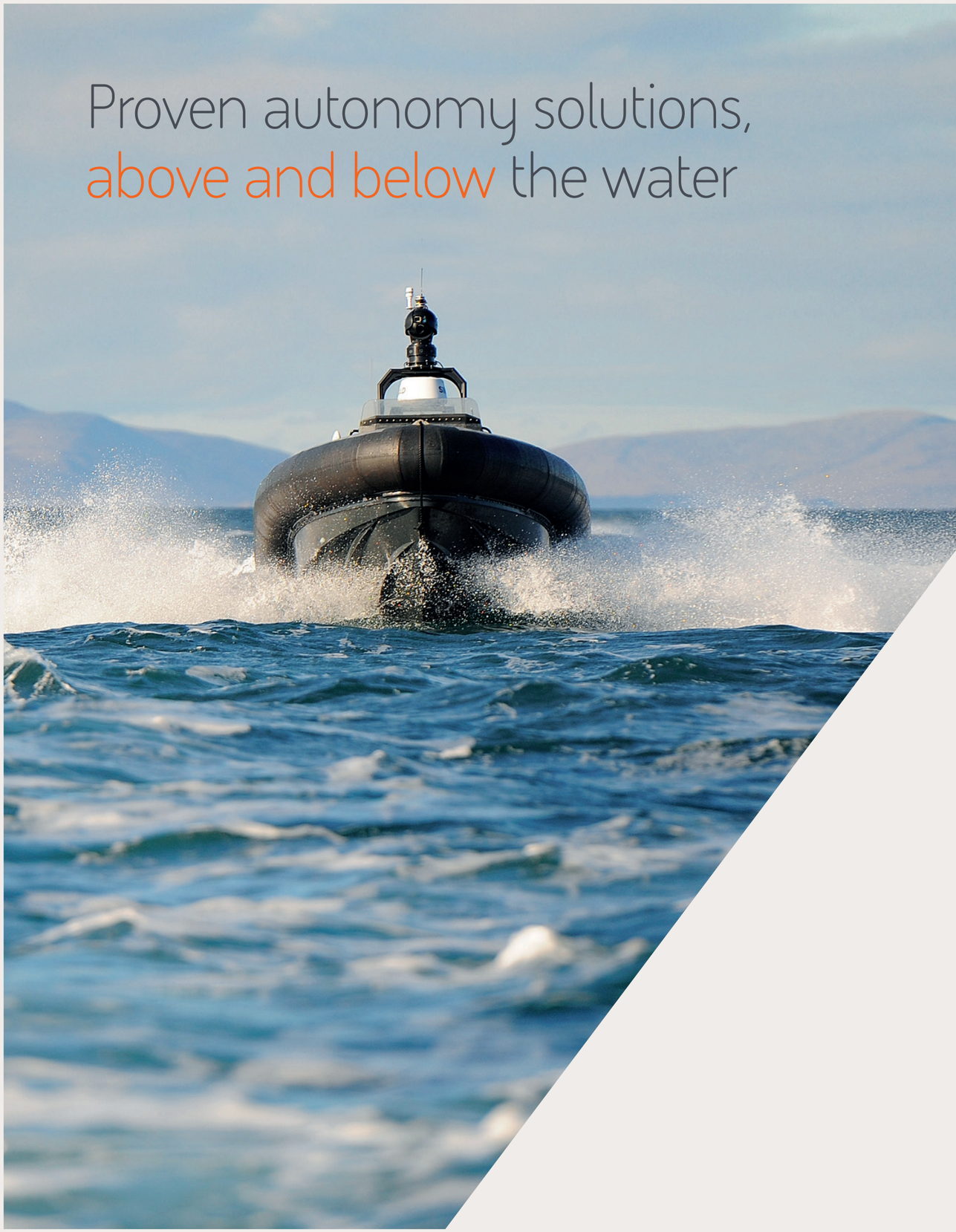
Our technologies help protect people from the most hazardous mission scenarios, grow maritime capability even when recruiting skilled seafarers is challenging, and drive success in complex, rapid-tempo and collaborative mission delivery.

baesystems.com/autonomy

Nautomate®

BAE SYSTEMS

Proven autonomy solutions, above and below the water



Autonomous platforms grow maritime capability

In an environment where technology solutions must keep pace with regulatory and operational requirements, our solutions provide the safety and security assurance needed to dependably deliver complex missions. Open interfaces to our proprietary core provide unparalleled versatility and upgradeability.

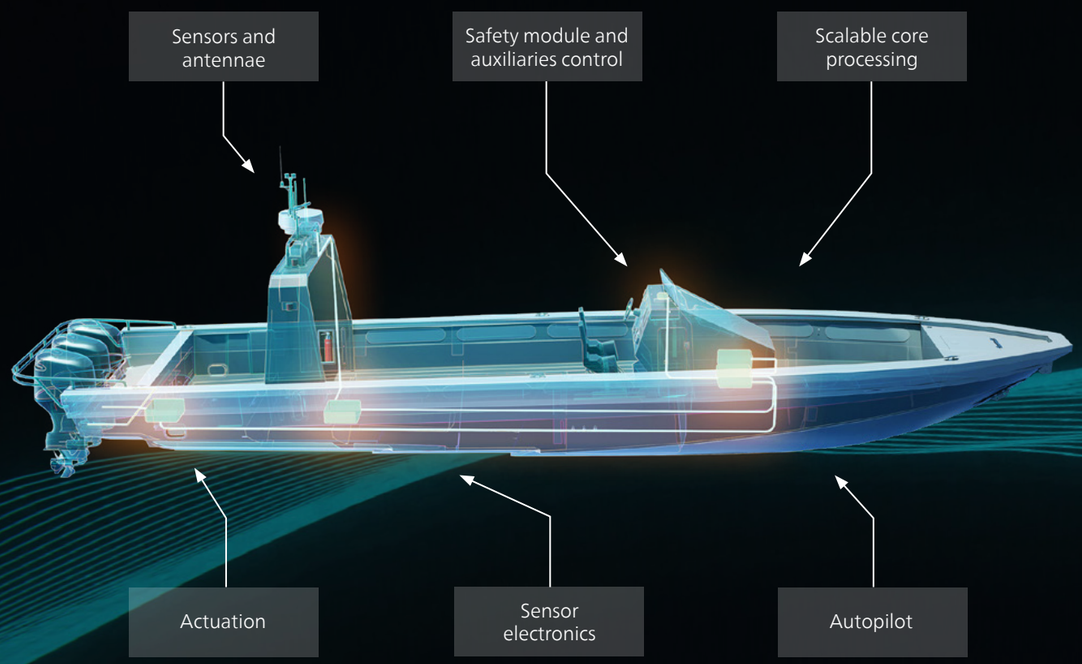
Autonomous technologies help remove people from the most hazardous mission scenarios

Autonomy is the key to generating increased operating scale, persistence and capability in dangerous environments. Typical applications include intelligence gathering, border enforcement, maritime security and force protection.

Nautomate® is a high specification autonomous military control system

The Nautomate® next generation military autonomous control system for un-crewed marine vehicles provides assured mission delivery in complex, congested and contested environments.

Designed, built and supported by experts from Europe's largest Defence Contractor, it provides dependable solutions based on a safety and cyber-security assured architecture. It can be designed-in for new platforms or retro-fitted to existing platforms.



Nautomate® has a common architecture that can be integrated in to surface and sub-surface platforms, and is platform agnostic, allowing it to be fitted to a range of third party platforms, providing flexibility for customers.

Easy to use:

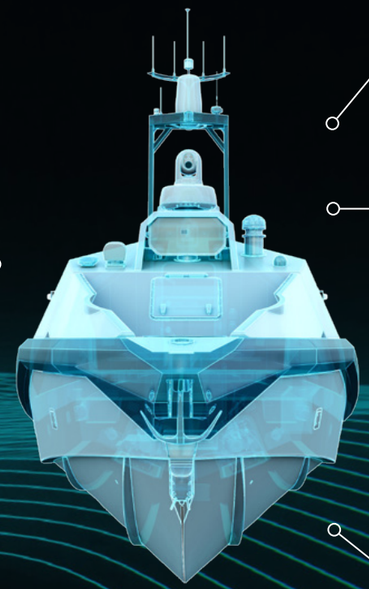
- Intuitive user interface
- Supports both S57 and S63 electronic charts
- Also supports OpenSeamap and World Vector Shoreline
- Automated route checking
- Intuitive instrument dashboard
- Multiple camera views
- On-board and remote data logging
- Comprehensive interactive electronic manuals

Capable:

- Pre-planned and autonomous mission types
- Supports a range of levels of autonomy
- Complies with part B of 1972 COLREGS navigation requirements
- Build complex missions from simple building blocks
- Seamlessly integrate with command and control systems
- Add custom mission capability using plug-ins written in any language

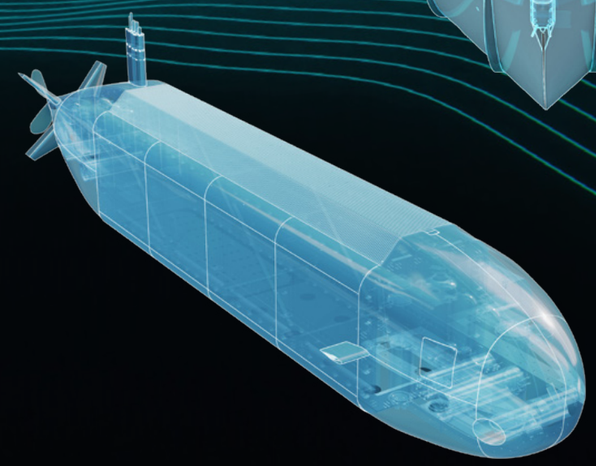
Assured:

- Safety functions assured to SIL 2 in line with IEC 61508
- Satisfies requirements of UK MASRWG code of practise
- Follows security by design principles



Easy to upgrade:

- Optional plug-ins for custom mission requirements
- Powerful dry-side scripting options
- Open interfaces to a proprietary core



Easy to Integrate:

- Scalable and extensible through open interfaces
- Custom C2 adaptors for MAPLE and other formats
- Supports multi-level security Architectures

An autonomy solution for small and medium sized vessels

Nautomate® is an autonomy solution for surface and sub-surface vessels. The scalable architecture makes it well suited for platforms between 6m and 50m in overall length.

Nautomate® can be retro-fitted to existing platforms or designed-in from the ground up for new vessels.

Powered by Nautomate®

Scalable autonomous capability

Nautomate® has the capability to operate across the full range of levels-of-autonomy. From direct operator "remote control" through to completely autonomous.

Human on board — Level of autonomy — Autonomous

Level 0	Level 1	Level 2	Level 3	Level 4
Human on-board	Human directed remotely operated	Delegated operation	Automation of end-to-end missions	Fully autonomous
...with no automation.	..."hands and eyes on" direct "tele-operation" style remote control with basic assist functions such as speed control, heading hold and dynamic positioning.	...but requires active human oversight "hands off, eyes on". Employing waypoint navigation and basic collision avoidance.	...with human interaction only required for more complex or critical decisions. Significantly reduced requirement for human oversight.	...able to carry out complex missions without need for human oversight.

BAE Systems provide the ability to operate across the full spectrum of autonomy. As experts in military integration, we specialise in the delivery of autonomy levels 3 and 4 for complex, high tempo, and long endurance missions or where communications may be compromised.

Our open architecture and modular mission plug-ins allow capability to be upgraded as technology advances predominantly in artificial intelligence guided tactics and decision making. This same flexibility supports the continuing evolution of new mission requirements and regulatory environments.

Safety Assured

We recognise the important role autonomy plays in the future of modern naval warfare. Our knowledge and experience underpins our ability to design and deliver complex autonomous solutions that meet stringent safety and operational performance standards.

Safety assurance is at the core of our autonomous control system, with safety systems physically and architecturally segregated, decision-makers can act with confidence. Architectural segregation between safety features and the rest of the system permits capability upgrades without the need for re-assurance.

Safety features

- Operator emergency stop system
- Geofencing - operating areas and keep-out zones
- Lost-communication protocol
- Last response emergency protocol

BAE Systems were the first company to be awarded Lloyds Register Unmanned Marine Systems Certification for a military vessel.

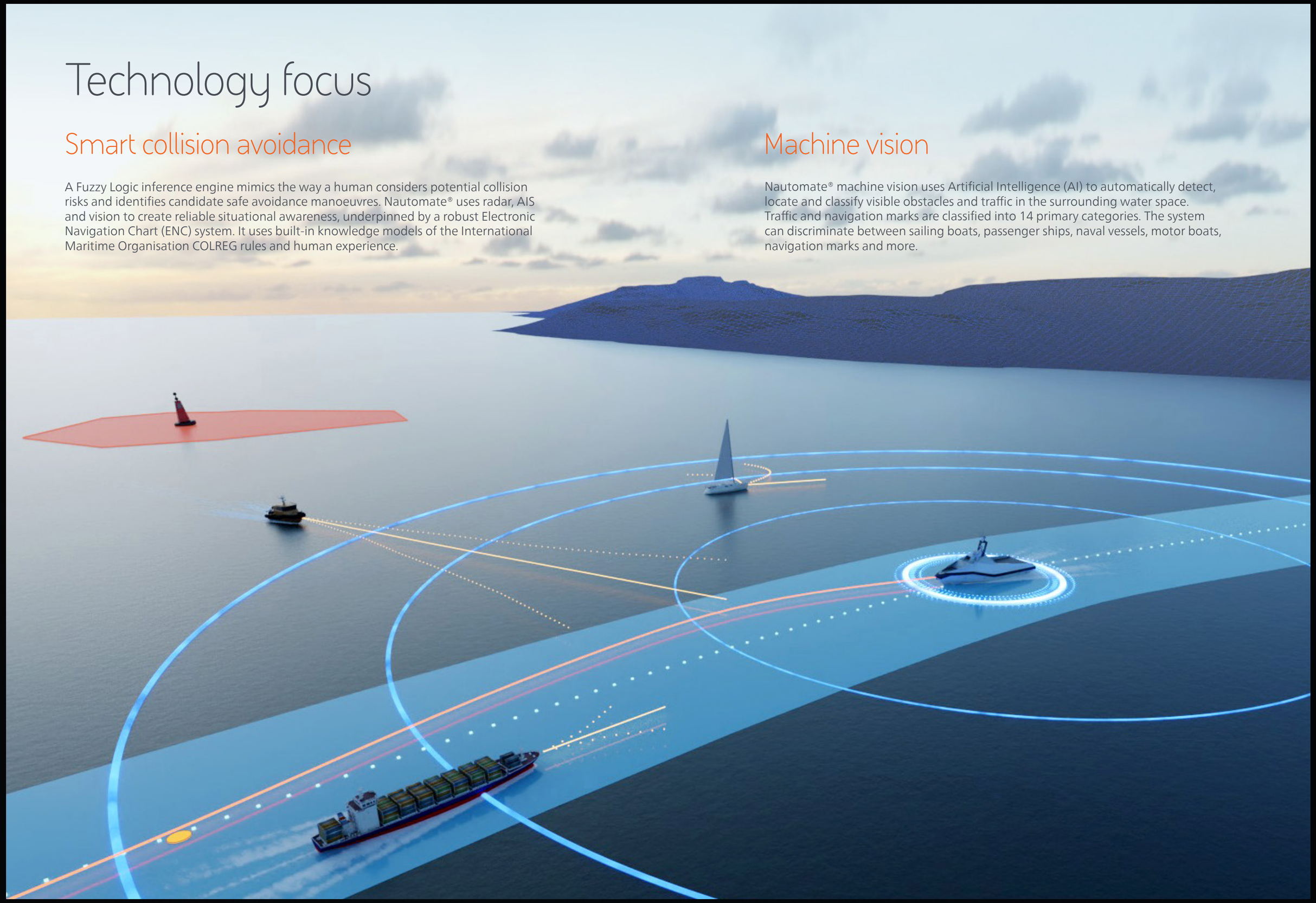
Technology focus

Smart collision avoidance

A Fuzzy Logic inference engine mimics the way a human considers potential collision risks and identifies candidate safe avoidance manoeuvres. Nautomate® uses radar, AIS and vision to create reliable situational awareness, underpinned by a robust Electronic Navigation Chart (ENC) system. It uses built-in knowledge models of the International Maritime Organisation COLREG rules and human experience.

Machine vision

Nautomate® machine vision uses Artificial Intelligence (AI) to automatically detect, locate and classify visible obstacles and traffic in the surrounding water space. Traffic and navigation marks are classified into 14 primary categories. The system can discriminate between sailing boats, passenger ships, naval vessels, motor boats, navigation marks and more.



Enhancing capability through mission plug-ins

Complex military missions often require bespoke functionality and algorithms, but these often attract a higher security classification or export control conditions. Encapsulating required mission specific behaviour in a plug-in prevents classification or export control from impacting the core architecture allowing custom capability to be created and licensed on an individual basis.

- Designed with an open data architecture which enables use of 3rd party plug-ins
- Plug-ins facilitate both the integration of custom payloads and sensors
- Users can pick from our growing library of existing plug-ins, commission the development of new plug-ins or create their own.

Compact command and control

Our portable command and control suite offers an optimised user experience, reduced training and cognitive burden. It allows operators to task and monitor mission operations using a sophisticated, intuitive, easy to learn graphical user system.

Route planning, behaviour primitives and mission plug-ins provide higher level autonomous mission options.

Advanced Electronic Charts

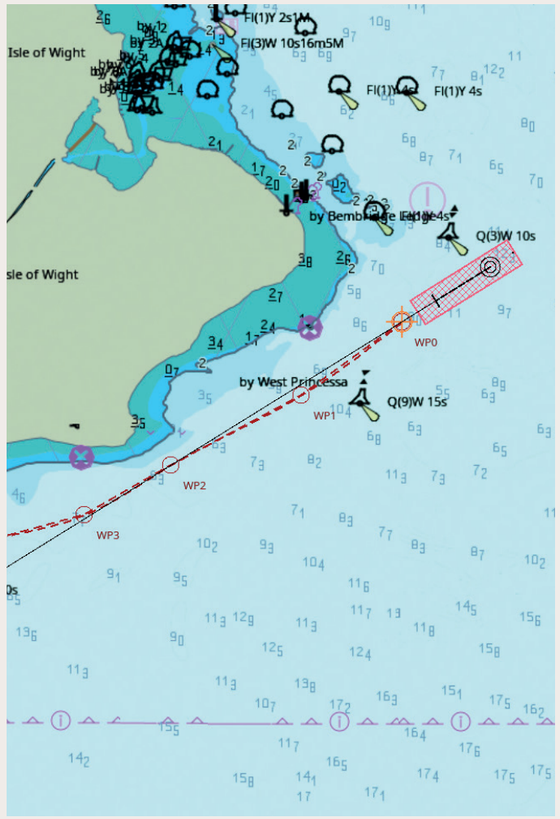
- A feature-rich Electronic Chart Display and Information System (ECDIS)
- Complies with IHO S-52 display standard
- Supports S-57 and S-63 electronic charts, S-100 support coming soon
- Comprehensive passage planning and route checking toolsets
- Visualises radar, AIS and visible obstacles as map overlays

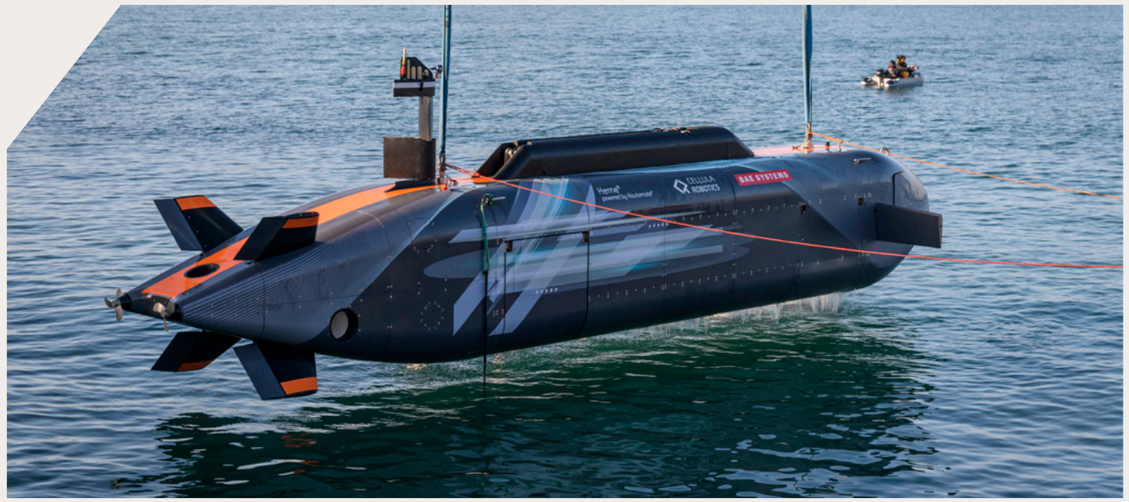
Simplified Dashboard

- Augmented reality live video provides real time, low latency situational awareness
- Simple, elegant electronic gauges provide critical instrumentation and alarms

Modular Mission Manager

- Construct complex missions from simple building blocks
- Extend and upgrade capability using mission plug-ins

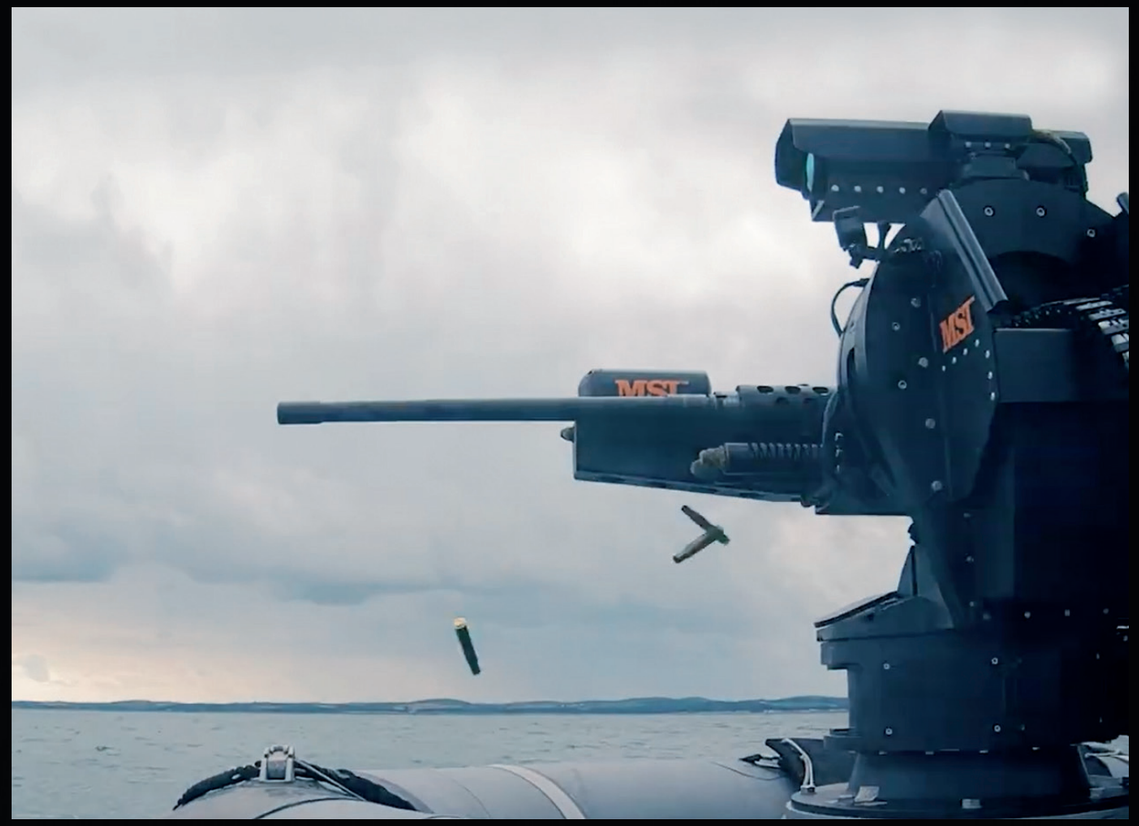


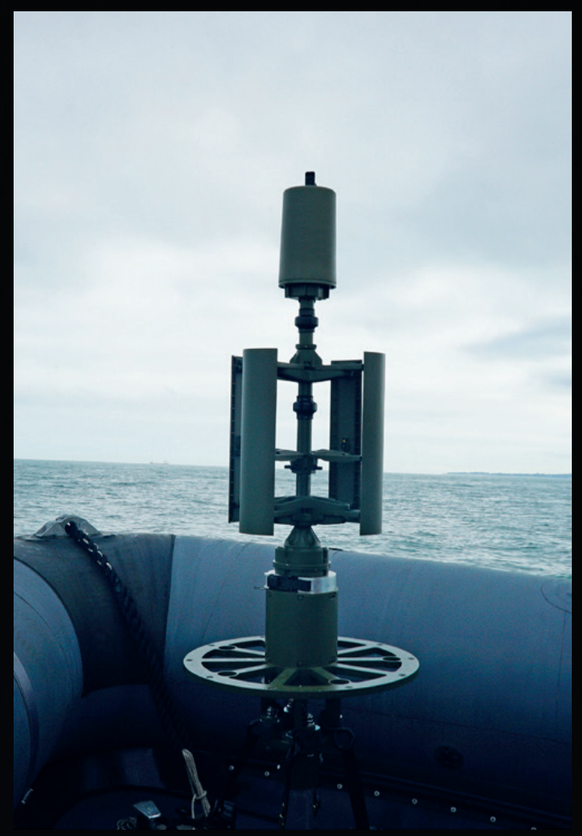


Versatile payload options

Leveraging our extensive knowledge of payload integration, the Nautomate® autonomy architecture allows a range of military and commercial payloads to enhance mission performance. Example payload options could include:

- Remotely operated weapon systems
- Non-lethal vessel arrest systems
- 360° panoramic & Pan-Tilt surveillance cameras
- Signal Intelligence (SIGINT) units
- Thin line acoustic towed arrays
- Acoustic hailing & warning systems





Technical Specs

Standard autonomy modes:

- Remotely piloted (teleoperation)
- Waypoint defined routes
- Behaviour primitives e.g. hold station, goto point, follow track
- Collision sensing and avoidance
- Route hazard checking
- IEC 61508 safety assurance to Safety Integrity Level 2 (SIL2)

Custom autonomous capabilities:

- Open interfacing standards
- Behaviour scripting
- Mission and payload specific software plug-ins
- Compatibility with the MAPLE C2 information architecture – with adaptors for other systems available on request

Standard Navigation Sensors:

- Satellite compass or twin GPS receiver with optional Inertial Measurement Unit
- X-band solid-state pulse compress navigation radar
- Class B or B+ AIS transponder
- 360° all-round high definition camera array
- Depth transducer

Auxiliaries Control:

- Lights, Anchor, Bilge, Fire Suppression etc

Core architecture:

- 11th Generation Tiger Lake i7 3.5" small form factor CPUs x4
- NVIDIA Jetson AGX Orin GPU (x1 minimum)
- Precision NTP time reference
- Secure by design architecture

Instrumentation:

- NMEA 2000 gateway
- Optional Engine Gateway as needed
- Equipment and compartment temperature monitors

Support Services:

- Powerful data logging (both aboard and remotely)
- Interactive electronic handbooks
- Flexible training packages
- Comprehensive through-life support

Communications:

- Encrypted end-to-end secure VPN
- L-band 20MB/s self-forming IP mesh radio bearer as standard
- Satellite communications for beyond line of sight operation (optional)
- Optional marine VHF radio interface (remote listen/talk/channel select)

Autonomy is making naval missions faster, easier and safer for militaries and first responders around the world

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