Developing a simple, usable and reliable assurance framework to enable wide scale MASS operations internationally

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About NPL

- UK’s National Metrology Institute founded in 1900
- A Government Laboratory owned by the Department for Science, Innovation and Technology (DSIT)
- Based in Teddington (London) with locations across UK
- 1200 staff plus 200 PGRs across multiple sectors and technologies.
- Enabling confidence in adoption of emerging technologies
Maritime Autonomy: Opportunity and Challenge

• The Opportunity: Projected demand for Maritime Autonomy is predicted to grow to become a $10bn market by 2030. *

• Maritime Autonomy will over time fundamentally change the operating and business models of many maritime sectors, making their operations safer, more sustainable, and efficient. E.g.
  • Lean Crewing / Port Operations
  • Fleet Decarbonisation: energy management of hybrid & full electric propulsion
  • Offshore energy / renewables, fisheries & aquaculture, environmental survey
  • Maritime security and naval logistics

• The Challenge: A paradigm shift in how these unmanned / uncrewed technologies are tested and certified is required.
  • Without the capacity to assure maritime autonomous systems (MAS), exploitation and benefits shall be significantly inhibited, slowing/limiting innovation & ecosystem growth potential.

*Fortune insights
Assurance: Challenge and Approach

- Proportional
- Standards
- Defining Safe
- Responsibility
Maritime Autonomous Operations Spectrum

Different levels of interaction, complexity, infrastructure and risk
Requirement for common terminologies, specifications and standards

Port
Inland
Coastal
Open Seas

Bridge Assist / Nav Aids
Lean crewing
Remote Operations
Autonomous Operations

Above Surface
On Surface
Sub Surface
Standardising Complex Systems?

Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation.

Case Studies available at: Safer Complex Systems (raeng.org.uk)
Proposed Solution:
Maritime Autonomy Assurance Testbed (MAAT)

• Objective: To enable the **fastest adoption** of MASS technology, making autonomy **affordable & business viable**. Results in accelerated and increased realisation of benefits of earlier adoption of the technologies.

• Programme being developed in the UK, following a data-driven and evidence based approach to:
  
  • Deliver an internationally relevant assurance capability supported by pro-innovation standards, and not constrained by existing human centric regulatory frameworks.
  
  • Test, certify and operationally assure maritime autonomous technologies globally, from component through to System of Systems.

• Enabled through the development of validated and integrated test environments for Maritime Autonomous Systems combined with a detailed, common requirements methodology and an operational certification framework.

• Developed in partnership between National Physical Laboratory, Lloyd’s Register, UKHO, Met Office, WMG (University of Warwick), PSD Freeport, University of Plymouth and Plymouth Marine Lab (…and growing).

• Draws on experience across autonomous mobility

• Designed to be a networked capability, across the UK

• **Establishing International collaborations**
Traceability back to well-structured requirements

Assurance through the lifecycle? i.e. Ubiquitous, efficient and assured Operations

Owner / Operators ‘The Need’

V&V for MASS

Benefits:
• Clarity of project relationships
• Enhances process visibility
• Increases efficiency & quality
• Improves impact / change analysis
• Demonstrates Verification & Validation
• Clarifies Contractual task ownership
• Proves functional safety

Operational Design Domain

Requirements

Yards / Original Equipment Manufacturers / Suppliers

assurance that every requirement is satisfied

link between need & derived requirement

Class Societies / Yards / OEMs

Regulators / Insurers

Source: Lloyd’s Register
Hypothetical: Assurance as a Service Model

**Approval & Authorisation**
- Approval and Certification
- Software / Firmware / Hardware Updates tested in digital model of system
- Analysis of operational Data against living log of system
- Generation of Test Plans
- Re-Authorisation

**Operational System**
- Analyses / communicates on:
  - Status of vessel
  - Status of vessel systems
  - ‘System learning’
  - Incident
  - Accident

**Assurance Platform**
- Provides a bridge for system owners / operators to compare the operations of systems against expected performance

**Sub system**
- Whole System
- System of systems

**Management**
- Confidence in and Optimisation of operational use cases and assets:
  - Owner / Operators
  - End Users
  - Port / Infrastructure
  - Insurers / Finance

**Risk Quantification**

**Operations Advisory**

**Data Trustworthiness**
- "Hierarchy of Loss"
- Infrastructure requirements

**Event Triggers / Self Diagnostics?**
MAAT: A Data-Driven Approach to Assurance

Measuring true capabilities and limitations of the system

Data Governance, Quality Frameworks and Usability

Linked & validated physical and virtual test environments

Standards for common vocabulary, test scenarios, taxonomies.

QA of Situational Awareness

Infrastructure – Digital and Physical

QA of Navigation decision making

Trustworthy AI
Establishing and measuring true capabilities and limitations of the system

Performance Pillar = Safety Assurance

Test Scenarios → Process → Safety Evidence / Safety Argument

Towards a Certification Framework
Enabling automated transport across maritime safety

Common taxonomies required
Developing the evidence base

- Day 1- Smart Sound Digital: 1000km² of deconflicted Test Infrastructure
- Supports development of assurance tools, data and test standards:
  - Data for Libraries for Operating Conditions and Behaviours and the development of Digital COLREGS
  - Test Scenario development
  - Reference Data for Sensor Assurance Framework and provides reliable environmental and sensor models for Virtual Testing
  - Training Data Library in accordance good practice guides for ML compliance assurance
  - RT Situational awareness of test areas & sound for remote operations – provides blue-print for wider deployment
  - Human Factors Analysis
- Networked structure shared and integrated across the UK and internationally, to support ‘distributed assurance capability’ and provide a scalable innovation platform.
Test Environments: Synthetic and Virtual Testing

To enable the **fastest adoption** of technology, making autonomy **affordable & business viable**.

**Requirement for adoption of autonomous technology:**
Develop and prove technology is safe, effective and dependable in real-world scenarios through testing and validation.

**Challenge:**
Real-world testing is expensive, time intensive and unpractical, as testing must be safely carried out in millions of operational scenarios / environments that might not occur in the real world for years.

**Synthetic Test Bed as a solution:**
An STB would create a fast, affordable and more effective alternative to real-world testing, by creating synthetic environments* and scenarios in which to perform testing and validation of technology for autonomy.

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*Essential to provide a quantified and traceable approach to ensuring that the models used in the virtual testing scenarios are a sufficiently accurate reflection of conditions and performance in the real world.

- Main question: **how can we be confident that performance in the virtual environment reflects performance in reality?**
- Related question: **how can we make the process cost-effective?**
Virtual Test Environments: requirements

Figure 1: Modules for consideration in a Virtual Testing Environment. Orange modules represent hardware modules, while blue modules represent software modules. Lighter blue modules contain mostly Commercial Off The Shelf (COTS) software. Interfaces and relationships between modules are not shown.
Common definitions and understanding

• Test scenarios and outputs
• Operating Domain taxonomies
• Autonomy levels
• Machine readable charts
• Maritime definitions for MASS - ‘vessel’; ‘responsible person’
An ambition to ‘make waves’

“To enable the **fastest adoption** of MASS technology, making autonomy **affordable & business viable**.”

“An international challenge requiring **international collaboration**.”

Driven by clear economic and social imperatives.

Underpinned by science, following an evidence based approach

Developed by a growing roster of leading research & innovation organisations in the UK

International collaboration is core to the programme

“An international challenge requiring **international collaboration**.”

**MAAT**

Maritime Autonomy Assurance Testbed

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**An international challenge requiring international collaboration.**
Thank you!

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