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Autonomous ships - what does the foreseeable future hold

Edward Fort, Global Head of Engineering, Lloyd’s Register
Insurance Institute of London, Marine & Energy 06 December 2017
The world around us is set to become autonomous. What do we mean by autonomy and what does this mean for shipping both in the near future and in the longer term. The design of modern ship’s with their complex, highly integrated, software controlled systems still assumes the presence of a crew on board capable of assuming control in the event of the unexpected and perhaps surprisingly much of the expected. While autonomy represents a solution to a number of major challenges the industry is facing unsurprisingly it also brings several challenges of its own.
Autonomous ships - what does the foreseeable future hold

- Autonomy, autonomous and autonomous systems
- Autonomy levels
- Autonomous ships and Cyber Enabled shipping
- Technical challenges
- Foreseeable future for autonomous ships
Autonomy, autonomous and autonomous systems

**Autonomous vehicles** or **Unmanned Systems (UMS)** are already established in many applications.

- **ROV** – Remotely Operated underwater Vehicle
- **AUV** – Autonomous Underwater Vehicle
- **UUV** – Unmanned Underwater Vehicle
- **UAV** – Unmanned Aerial Vehicle
- **UGV** – Unmanned Ground Vehicle
More *autonomous vehicle* applications are beginning to emerge including
Self driving vehicle
Autonomous aerial taxi
Remotely operated surveillance drone
Autonomy, autonomous and autonomous systems

The development of military and industrial **Unmanned Systems (UMS)** and **Autonomous Vehicles** has without doubt been **demand-driven**. Is the same true for more recent developments?

Figure 25. Challenges to existing human-machine systems and opportunities for autonomous capabilities

Combines figures 1 – 4 in: Technical Assessment: Autonomy, DoD, Office of Technical Intelligence, Office of the Assistant Secretary of Defense for Research and Engineering, Feb 2015
Autonomy, autonomous and autonomous systems

**Autonomy and autonomous**
- Act separately, self-governing,
- Control over own actions,
- Self-directed behaviour,
- Modify own behaviour
- Adapt to changes in environment
- Independently compose and select actions

**Autonomous systems**
- Systems that are able to independently compose and adjudicate among a set of possible actions to accomplish goals based on their knowledge and understanding of the world and themselves, and able to adapt to dynamic contexts in their environment
Autonomy levels are “a set of progressive indices, typically given in numbers, identifying a UMS’s capability for performing autonomous missions”

Essentially...
the degree of human/machine interaction
Different industries and different industry groupings are beginning to establish their own **autonomy levels** according to the needs of their application…

**Autonomy levels**

 unsquare

**SAE J3016 on-road motor vehicle automated driving systems**

**Unmanned Maritime Systems - SARUMS**
Lloyd’s Register considers autonomous ships an aspect of **Cyber Enabled Shipping** enabled by recent developments in digital and data technologies.
For the foreseeable future the world's shipping fleet will comprise ships with varying degrees of **cyber enabled access** to some or all of their systems on-board.

**AL0**
- No cyber access

**AL1**
- Manual cyber access

**AL2**
- Cyber access for autonomous/remote monitoring

**AL3**
- Cyber access for autonomous/remote monitoring and control
- Onboard permission required
- Onboard override possible

**AL4**
- Cyber access for autonomous/remote monitoring and control
- Onboard permission not required
- Onboard override possible

**AL5**
- Cyber access for autonomous/remote monitoring and control
- Onboard permission not required
- Onboard override not possible
Autonomous ships and Cyber Enabled Shipping

Autonomy level AL1 - **Normal Manning**. Its systems are **not externally accessible** for either monitoring or control. The majority of the world's commercial fleet is AL1.
Autonomous ships and Cyber Enabled Shipping

Autonomy level AL2 - Normally manning. One or more essential systems are externally accessible for monitoring. Much of the tonnage delivered in recent years is AL2.
Autonomous ships and Cyber Enabled Shipping

Autonomy level AL3 - **Normal manning.** One or more essential systems are **externally accessible for monitoring and control.** Some of the tonnage now being delivered is AL3.

**AL0**
- No cyber access

**AL1**
- Manual cyber access

**AL2**
- Cyber access for autonomous/remote monitoring
  - onboard permission required
  - onboard override possible

**AL3**
- Cyber access for autonomous/remote monitoring and control
Autonomous ships and Cyber Enabled Shipping

Autonomy level AL4 – **Reduced manning possible.** One or more essential systems are **externally accessible for monitoring and control.** Such ships are currently under development.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>AL0</td>
<td>No cyber access</td>
</tr>
<tr>
<td>AL1</td>
<td>Manual cyber access</td>
</tr>
<tr>
<td>AL2</td>
<td>Cyber access for autonomous/remote monitoring</td>
</tr>
<tr>
<td>AL3</td>
<td>Cyber access for autonomous/remote monitoring and control&lt;br&gt;onboard permission required&lt;br&gt;onboard override possible</td>
</tr>
<tr>
<td>AL4</td>
<td>Cyber access for autonomous/remote monitoring and control&lt;br&gt;onboard permission not required&lt;br&gt;onboard override possible</td>
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Autonomous ships and Cyber Enabled Shipping

Autonomy level AL5 – **Zero manning possible.** One or more essential systems are *externally accessible for monitoring and control.* Such ships are currently conceptual at this point in time.

- **AL0**
  - No cyber access

- **AL1**
  - Manual cyber access

- **AL2**
  - Cyber access for autonomous/remote monitoring

- **AL3**
  - Cyber access for autonomous/remote monitoring and control
  - Onboard permission required
  - Onboard override possible

- **AL4**
  - Cyber access for autonomous/remote monitoring and control
  - Onboard permission not required
  - Onboard override possible

- **AL5**
  - Cyber access for autonomous/remote monitoring and control
  - Onboard permission not required
  - Onboard override not possible
While the technology for autonomous ships is already available its introduction does pose some **major technical challenges** for traditional marine engineering systems including:

- Equipment suitability
- Fault tolerance
- Software verification
- System scope
- System assurance
Foreseeable future for autonomous ships

LPG Carrier AL2 (Navigation, Cargo Handling, Machinery) AL3 (HVAC)

Bulk Carrier AL2 (Navigation, Propulsion, Steering)
Foreseeable future for autonomous ships

Harbour tug AL3 (*Navigation, Propulsion, Steering*) - Phase 1

- **AL3**
  - Cyber access for autonomous/remote monitoring and control
  - Onboard permission required
  - Onboard override possible

- **AL4**
  - Cyber access for autonomous/remote monitoring and control
  - Onboard permission not required
  - Onboard override possible
Foreseeable future for autonomous ships

So are autonomous ships an example of technology looking for an application...

*Without doubt* **autonomous ships** *can be expected to operate with optimum efficiency* however *from a safety perspective* **autonomous ships** *should solve the ever widening gap between the complex, interdependent, software driven systems being installed on modern ships and the competence and capability of the ships crew to operate and maintain those systems*  

However autonomous ships could ultimately provide solutions to what are arguably the biggest challenges the shipping industry faces...

**Autonomous ships** without the crew onboard would eliminate the single biggest cause of accidents and incidents onboard ships – **human Error.** And if that’s not enough, **autonomous ships** without the cost of the crew onboard might make increased numbers of much slower significantly more fuel efficient ships a major part of the solution to the greatest challenge that ships will need to overcome – **decarbonisation**
Foreseeable future for autonomous ships

REMOTE CONTROL/OPERATION
- Monitoring & Control
- Navigation & Piloting
- Operation of payload systems

CONDITION MANAGEMENT
- Health monitoring
- Self diagnostics
- Smart maintenance schemes
- Remote support
- Maintenance robots

NAVIGATION & POSITIONING
- Situation awareness & Sensing
- Dynamic Positioning & Auto pilot
- E-Navigation

DECISION SUPPORT
- Navigation (e.g. Routing)
- Situational awareness
- Collision avoidance
- Safety support

OPERATIONS OPTIMISATION
- Onboard energy optimisation
- Fleet optimisation
- Revenue optimisation

ONBOARD AUTOMATION
- Automatic reporting
- Automatic systems (e.g. Mooring)
- Robotics
- Full autonomous operation

Image Rolls Royce
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