



WHEN TRUST MATTERS



# Autonomous & Remotely Operated Ships (AROS)

自主船舶船員與遠端操作人員的適任能力

2025.12.16

吳文仁 主任驗船師/ Taipei

28 May 2025 (updated 16 Dec 2025)

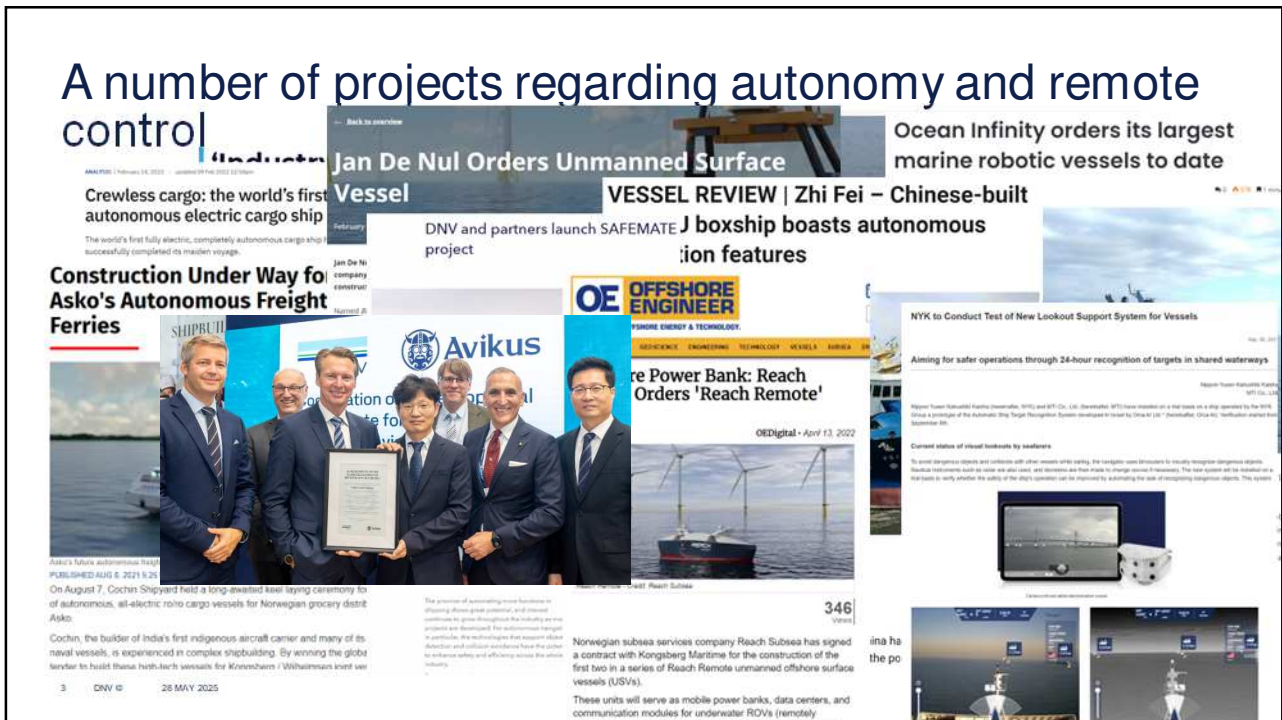
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現行AROS船舶簡例  
INDUSTRY LEADS



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## Yara Birkland

**Announced:** May, 2017

- All electric, Length: 80m, Width: 15m; 10Kn
- 6.7 MWh battery, two propulsion thrusters, two bow thrusters
- Route: Herøya - Brevik - Herøya, 28NM, 3h
- Cargo: 120 TEU containers loaded with fertiliser

**2024:** Temporary permit, 5 crews

Two year period for installation and testing of autonomy with remote operations centre in Horten

**May 2025:** over 250 voyage

**Goal:** Unmanned, mainly autonomous operation



4    DNV ©    28 MAY 2025    Source: [World's First Fully Electric Autonomous Container Vessel, Yara Birkland, Celebrates 3 Years of Service | Corporate - EOS News](#)

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# REACH REMOTE USV

1A
Battery(Power)
Recyclable
ER(SCR)

**30** (Operational Cost Savings: Estimated 20–30% reduction in operating costs)

**65** (Size Reduction: ~60–65% smaller in length)

**100** (Emissions Reduction: Up to 90–100% reduction in greenhouse gas emissions)



Source: [Riviera - News Content Hub - First Reach Remote uncrewed surface vessel launched](#)

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## Focus areas for assurance of autonomous functionality

Overall acceptance criteria: At **least as safe** as conventional ship operations



**Navigation**

- Object detection (navigational hazards)
- COLREG compliant manoeuvring
- Total situational awareness
- Robustness of systems
- Handling of failures



**Engineering**

- Robustness of machinery and systems
- Alert management
- Maintenance and troubleshooting
- Handling of failures



**Connectivity**

- Coverage
- Bandwidth and latency
- Redundancy
- Cyber security
- Handling of failures



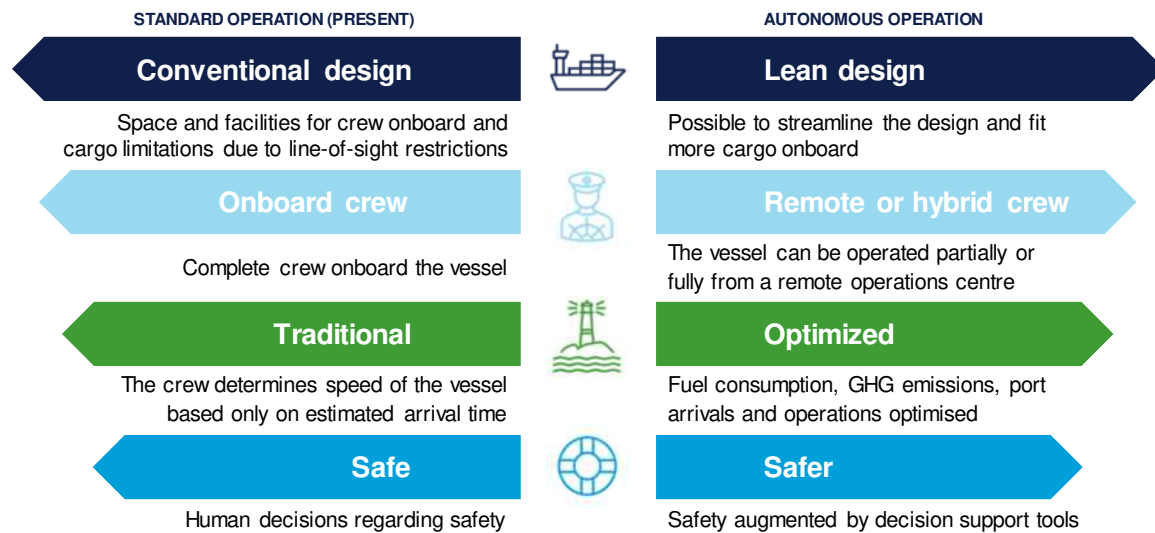
**Remote operations centre**

- Situational awareness
- Handling of individual ships
- Fleet-level handling
- Emergency situations
- Handling of failures

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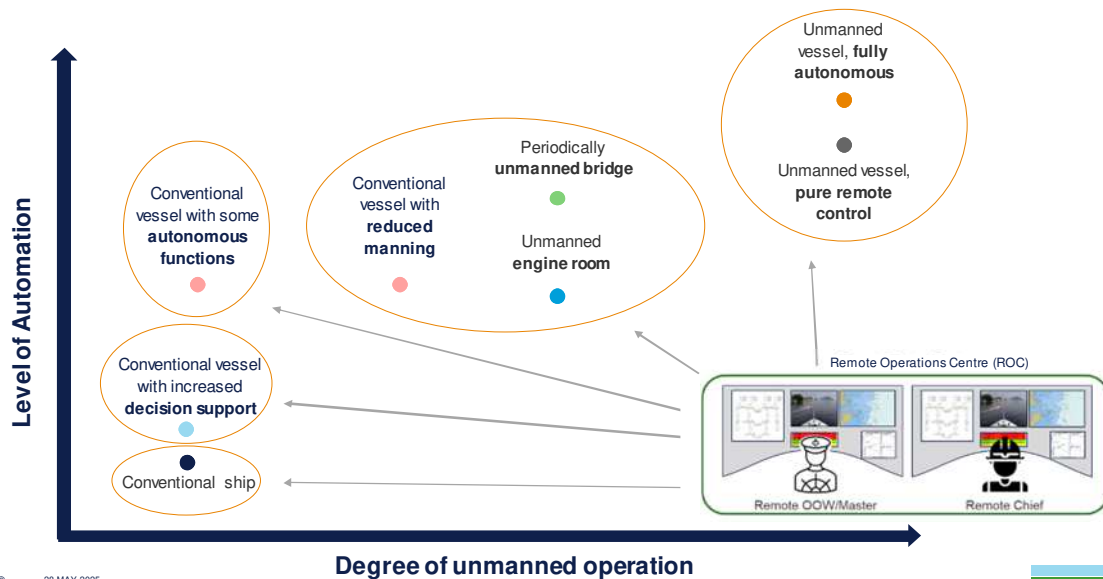
# The promises of autonomy



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# Many different 'autonomy' concepts being proposed & developed



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# IMO的法規進程

## IMO MASS code

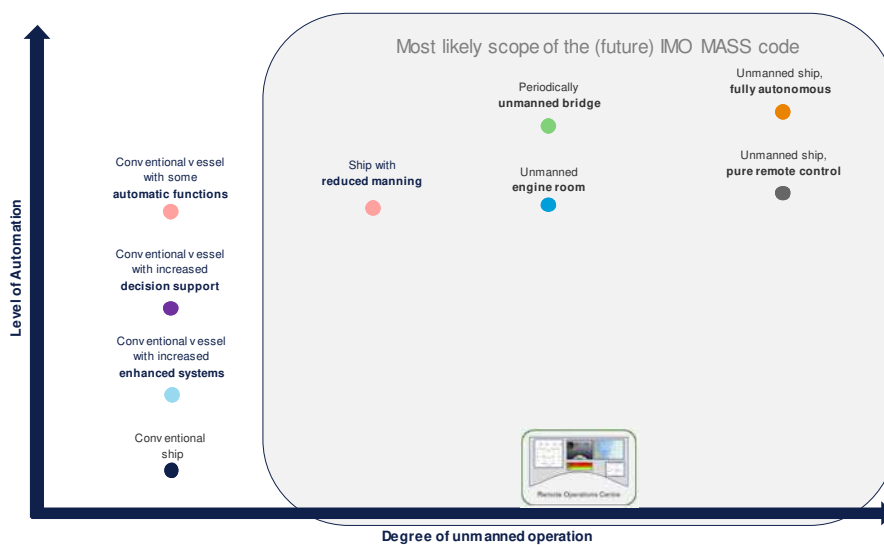
(Maritime Autonomous Surface Ships)

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### Mapping towards the future MASS code

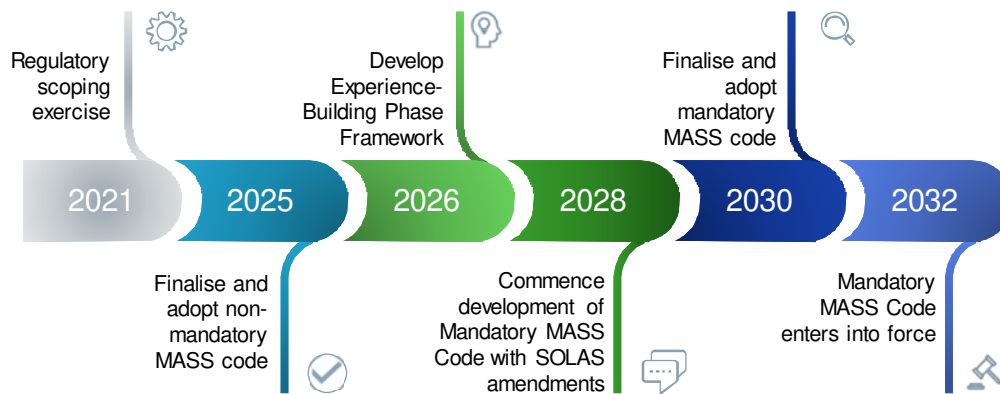


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## MASS code timeline overview



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## Main decisions made regarding the mass code

- Goal based (Goals → Functional requirements → Expected performance)
- For **cargo ships** only
- Supplementary to SOLAS and other existing instruments
- **Risk analysis** will be a part of the approval process
- There are no “levels of autonomy”, only **different modes of operation**
- There shall be a **human master** responsible for the vessel
- The master may not be on board, depending on the mode of operation, technology, and presence of other persons onboard
- There may be a handover between masters during a voyage, but **only one master** at the time will supervise and control the vessel
- The master shall have **the means of intervening** when necessary
- If abnormal situations occur, the vessel shall be able to go into one or several predefined fallback states

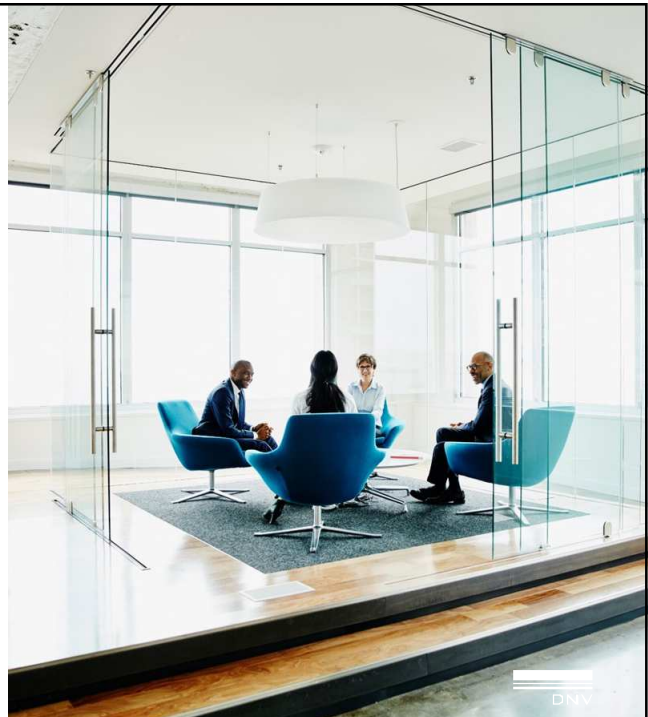
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## MASS code - main current discussions

- Certification and survey
  - **Certification** of remote operations centres (ROC)
  - **Survey** schemes
  - How will MASS certificates relate to existing certificates?
- Human element
  - **Roles and responsibilities**
  - **Competency** requirements
  - **Manning** of ROCs
- Search and rescue
  - Requirements regarding **rescue** capabilities



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## What about the legal aspects?

- **IMO Conventions** SOLAS, COLREGS, MARPOL, ...

- Written for m
- References
- Requires of

STCW VIII/2.1  
*“officers in charge of the navigational watch are responsible for navigating the ship safely during their periods of duty, when they shall be physically present on the navigating bridge or in a directly associated location such as the chartroom or bridge control room at all times”*

- **Flag-states may however:**

- Grant exemptions and approve alternative solutions to allow novel operational concepts **within national waters** when this is applied for.



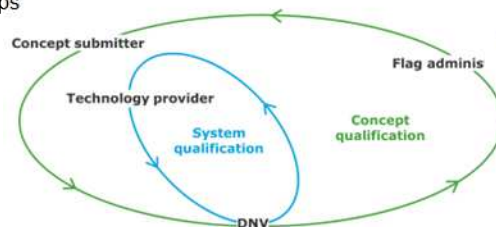
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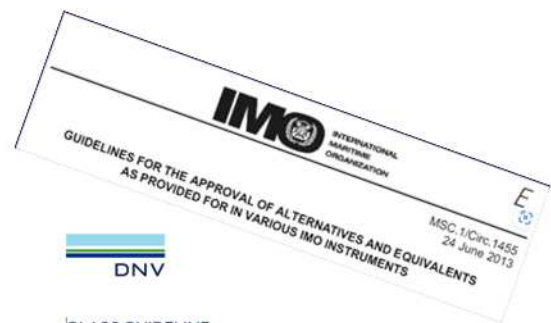
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## Flag state regulation

- **Flag-state approval** is necessary if the autoremate vessel does not comply with manning and operational regulations.
- Flag-states may allow autonomous ships operations and approve alternative solutions within **national waters** using MSC.1/Circ.1455
- The Concept Qualification for AROS notations, outlined in DNV-CG-0264 is aligned with MSC.1/Circ. 1455.
- The process to obtain AROS notations can be used as baseline to obtain flag approval for autonomous and remotely operated vessels operation in national waters.
- Concept approval loops



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CLASS GUIDELINE

DNV-CG-0264

Edition December 2024

**Autonomous and remotely operated vessels**



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# 從DNV船級法規看MASS DNV notation, AROS

DNV-RU-Pt.6 Ch.12 & DNV-CG-0264

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# Qualifying for an AROS class notation

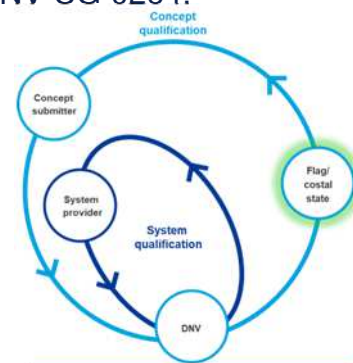
The qualification to an AROS Class Notation consists of a **Concept Qualification** and a **System Qualification**, both processes combine AROS functional requirements with a risk-based process defined in DNV-CG-0264.

### Concept Qualification

To **obtain approval from the maritime authorities of novel vessel concepts** which challenge existing statutory regulations.

### System Qualification


For verification of a safe implementation of **novel (use of) technologies** in autonomous and/or remotely controlled vessel functions.







Compatible with IMO MSC.1/Circ.1455

# DNV AROS class notations contains three parts


**Functional Categories**







**Four Categories of Functions**

-  Navigation
-  Engineering
-  Safety
-  Operations

**Modes of Operation**



**Four Modes of Operation**

-  Remote Control
-  Decision Support
-  Supervised Autonomy
-  Full Autonomy

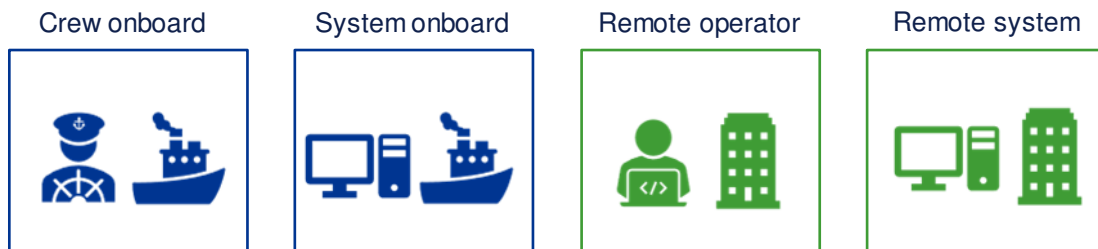
**Location of Control**



**Three Locations of Control**

-  Onboard Control
-  Off-ship Control
-  Hybrid Control

## Allocating responsibility of key ship functions

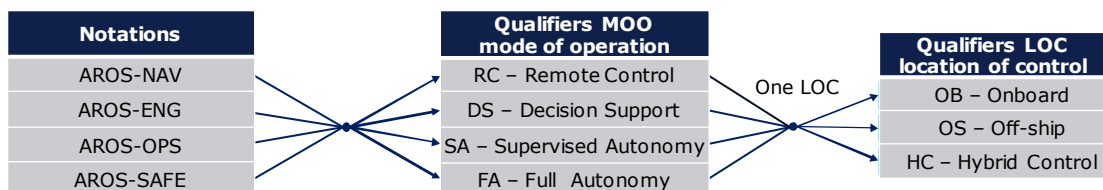


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## AROS notations

– A framework for approval of Autonomous and Remotely Operated Ships



Example 1: **AROS-NAV (DS, SA, OB)** - Collision and grounding avoidance systems on a traditional bridge

Example 2: **AROS-NAV (FA, OB)** - Periodically unmanned bridge (B0)

Example 3: **AROS-ENG (RC, OS)** - Remote machinery control from a remote operations centre

Example 4: **AROS-SAFE (RC, HC)** - GMDSS support from a remote operations centre

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## The human in the loop

### AROS Remote Control – Remote Operator:

Executes the actions necessary to maintain the vessel safe remotely, relies on the same information as a conventional navigator

### AROS Decision Support – Action Executor:

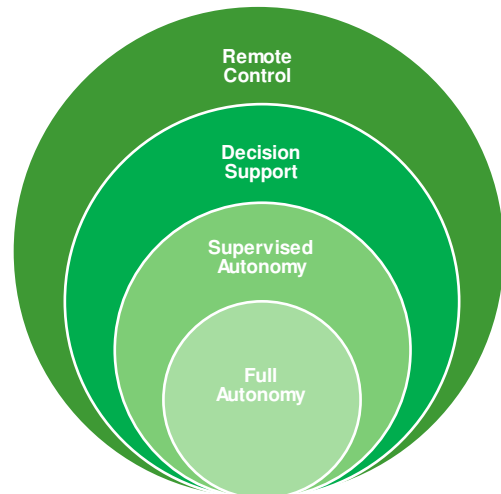
Executes the actions necessary to maintain the vessel safe, with the support of the system's advice.

### AROS Supervised Autonomy – Action Supervisor:

Is aware of the vessel status and ready to take over when the system's actions are not desirable, as well as in case of emergency.

### AROS Full Autonomy – Fallback Operator:

Only intervenes in case of emergency. Needs awareness of the system to be capable of intervening timely.



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## Modes of operation

The mode of operation defines the capabilities of the autoremote system and human involvement.

Remote Control	Decision Support	Supervised Autonomy	Full Autonomy
The autoremote system provides situational awareness to the operator, who operates the autoremote function completely.	The autoremote system advises the operator on possible courses of action. The operator decides to accept the system's advice or implement another action.	The autoremote system operates the function and informs the operator about planned actions. The operator acts as quality assurance and may override the system's actions when deemed necessary.	The autoremote system operates the function autonomously under normal circumstances. The operator has access to an overview of system's actions and may intervene when deemed necessary.

The operator may intervene and handle abnormal and emergency situations in all modes of operation.

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## •DNV-CG-0264, Class Guideline of AROV

### Objective

1) Safe implementation of novel technologies ARV functions o/b, and ROC & connectivity link.

2) Recommended work process challenging existing statutory regulations and/or classification rules.

>A framework ensures that application of such novel concepts and technologies result in a safety level equivalent to- or better than conventional vessel operations. details for **AROS** class notations.

- > Section 3 Qualification and approval process
- > Section 4 Navigation functions
- > Section 5 Engineering functions
- > Section 6 Safety functions
- > Section 7 Operations functions
- > Section 8 Modes of operation
- > Section 9 Location of control
- > Section 10 Remote operations centres
- > Section 11 Connectivity
- > Section 12 Bibliography

- > Appendix A List of fallback states
- > Appendix B List of potential autoremove functions
- > Appendix C Navigation systems - applicability of conventional carriage requirements for autore...
- > Appendix D Navigation systems - additional systems for autoremove vessels
- > Appendix E Simulator based testi...
- > Appendix F Additional risk assessment guidelines

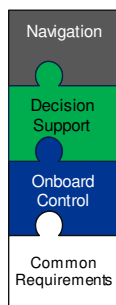
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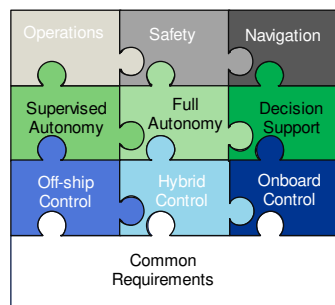
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## AROS Notations: A building block approach

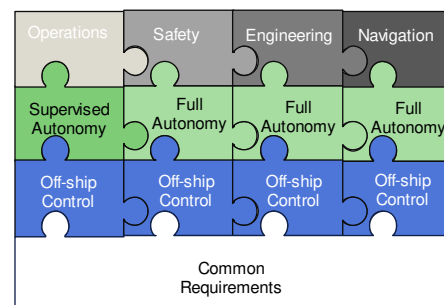
Each AROS Class Notation has multiple possibilities of combination with the two blocks of qualifiers, creating a flexible approach to serve various autonomous vessel concepts.



AROS-NAV(DS,OB)



AROS-NAV(SA,OB)  
AROS-ENG(RC,HC)



AROS-SAFE(FA,OS)  
AROS-OPS(SA,OS)

AROS-NAV(FA,OS)  
AROS-ENG(FA,OS)

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# 其他DNV規範

## Voluntary DNV documents

DNV-RP-0323, DNV-ST-0324, DNV-ST-0322

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## DNV-RP-0323 Certification scheme for remote operators of autoremove vessels



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- Section 3 Certification requirements
- Section 4 Competence development
- Section 5 Certification assessments
- Section 6 Certification bodies and examination centres
- Section 7 Equipment requirements
- Appendix A Sample certification scheme remote operators
- Appendix B Sample certificate remote operator

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# DNV-ST-0324 Competence of remote operators of autoremove vessels

## Background

- It can be applied for varying degrees of automation, and varying organizational set-ups where ROCs in ROCs of varying complexity may not monitor fully autonomous ships but remotely support a crew aboard.

## Scope

- minimum level of knowledge and skills for remote operators related to navigation and engine/machinery.

## Consequence

- In combination with DNV-RP-0323 Certification scheme for remote control centre operators, DNV SeaSkill™ services is to certify the certification bodies/ examination centres of ROCs.

- ▼ Section 3 Competence requirements
  - 3.1 General
  - 3.2 Operational scope
  - 3.3 Professional profile
  - 3.4 General competence requirements
  - 3.5 Bridge watchkeeping
  - 3.6 Engineering watchkeeping
- ▼ Appendix A Previously acquired competence
  - ▶ A.1 Competence foundation
  - A.2 Other suitability criteria

## DNV ST-0324 competence table (e.x. General)

- Knowledge
- Understanding
- Application
- Integration

ID	Competence activity <i>"The remote operator shall be able to ..."</i>	Required level of cognition
7.6.4	Perform a transfer between two physical locations (e.g. other ROC) without losing oversight and control	A
7.7	<i>Data analysis</i>	
7.7.1	Validate received data	I
7.7.2	Analyse available historic data to optimize the autoremove vessel operation	I
7.7.3	Evaluate a voyage	I
	<b>normal, abnormal and emergency situations</b>	
7.9	<b>Work on board the autoremove vessel</b>	A
7.9.1	State how external parties are granted access to the autoremove vessel	A
7.9.2	State the ROC's methods for overseeing maintenance and repair work on board	A
7.8.4	Communicate the technical state of both the ROC and the autoremove vessel to third parties in normal, abnormal and emergency situations	A
7.9	<i>Work on board the autoremove vessel</i>	
7.9.1	State how external parties are granted access to the autoremove vessel	K
7.9.2	State the ROC's methods for overseeing maintenance and repair work on board the vessel	K
7.9.3	Explain the use of work permits in an autoremove vessel / ROC setting	U
7.10	<i>Environmental settings</i>	



# DNV-ST-0324 Competence of remote operators of autoremote vessels



- ▼ Appendix A Previously acquired competence
  - ▼ A.1 Competence foundation
    - A.1.1 General
    - A.1.2 Certificate of competence (COC)
    - A.1.3 Specific competence
  - A.2 Other suitability criteria

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# DNV ST-0322 Management System in auto-remote operations



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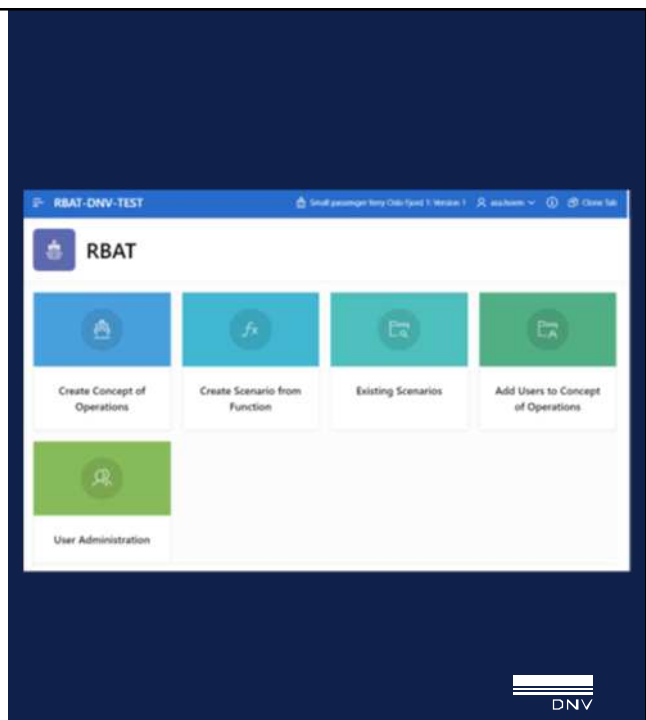


## RBAT Tool

### Method and tool developed by DNV on behalf of EMSA:

- Online tool facilitating the risk assessment process for MASS
  - Templates
  - Lists of functions and operational phases,
  - Guidewords
  - Risk matrices, etc.
- Protected with Two Factor Authentication
- The RBAT tool will be available during the autumn 2024.
- Free - EMSA decides who will get access.

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## How DNV has supported clients on MASS regulatory compliance

**Concept Qualification CQ support**

Comply with MSC 1/Circ. 1455 and DNV CG-0264



**Technology Qualification (TQ)**

How to qualify innovative technology?



**Risk Assessment facilitation**

HAZID, HAZOP, FMECA, RBAT

Proposed use of RBAT



**Cyber Security assessment support**

Physical & procedural, vessel and system barriers



**MASS Management System Support**

Safety management system remote control center operations



**MASS Simulator Testing**

COLREG compliance





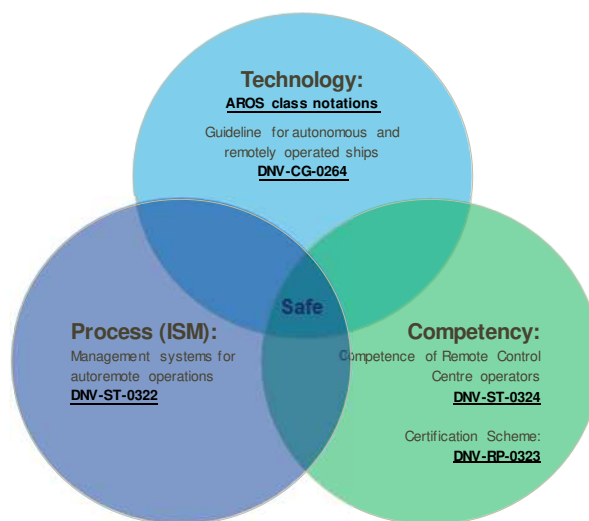
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# Conclusion

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## Technology alone cannot make the autoremote ship safe



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# Autonomous & Remotely Operated Ships (AROS)

:IMO MASS code, DNV class notations

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[DNV rules and standards](https://www.dnv.com/rules-standards/) (https://www.dnv.com/rules-standards/)

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