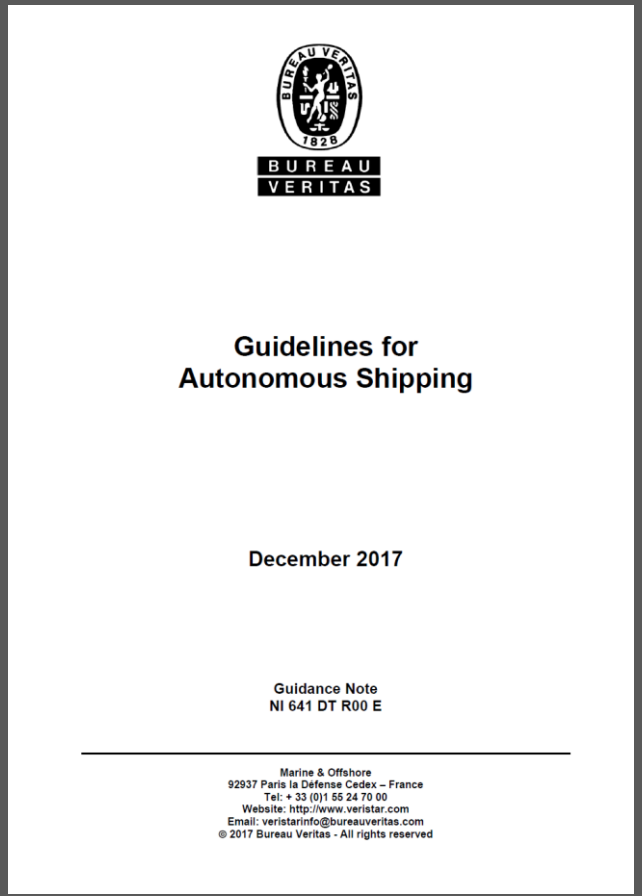
A set of Guidelines towards Autonomous Shipping

BUREAU VERITAS Marine & Offshore
Hall12, Amsterdam RAI – 25/06/2019

Jérôme FAIVRE
Smart Ships Rules Manager – Development Department



BUREAU VERITAS

Guidelines for Autonomous Shipping

December 2017

Guidance Note
NI 641 DT R00 E

Marine & Offshore
92937 Paris la Défense Cedex – France
Tel: + 33 (0)1 55 24 70 00
Website: http://www.veristar.com
Email: veristarinfo@bureauveritas.com

1/ NI 641

Guidelines for Autonomous Shipping
Draft April 2019

2/ IMO

Regulatory **S**coping **E**xercise (RSE)
for the use of
Maritime **A**utonomous **S**urface **S**hip (MASS)

3/ ISO

TC 8 / WG 10 / AWI 23860
Terminology related to automation of MASS

4/ EU SMART PROJECTS

BV M&O DV involvement

AUTONOMOUS SHIPPING VISION

Autonomous shipping – Why ?

Reduce

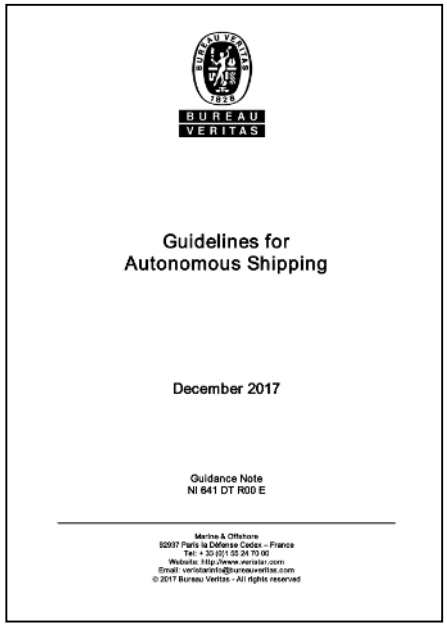
accidents, damages, spills
crew exposition to hazardous situations
fuel consumption & emissions
operating cost: less crew, fuel saving, design optimisation

Improve

safety & efficiency of operations
use of space & cargo capacity

Incremental growth expected

From small vessels operating locally to **large cargo ships**
From remote control to partial or **full autonomous**


Guidelines for
Autonomous Shipping

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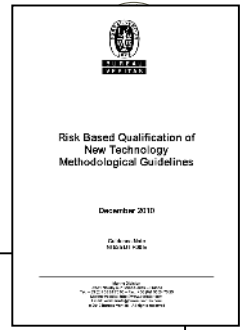
https://marine-offshore.bureauveritas.com/rule-notes-and-guidance-notes

Regulatory challenges

Statutory: Applicability and compliance with (inter)national regulations → **need to interpret / adapt regulations**
Class: Guidelines for Autonomous Shipping → **NI 641 December 2017**

BV APPROACH

NI 641 Guidelines for Autonomous Ships


Risk Based Qualification of
New Technology
Methodological Guidelines

December 2010

Risk and technology assessment

Risk identification and mitigation for autonomous ships

Risk based qualification of **new technology (BV NI 525)**

Functionality of autonomous systems

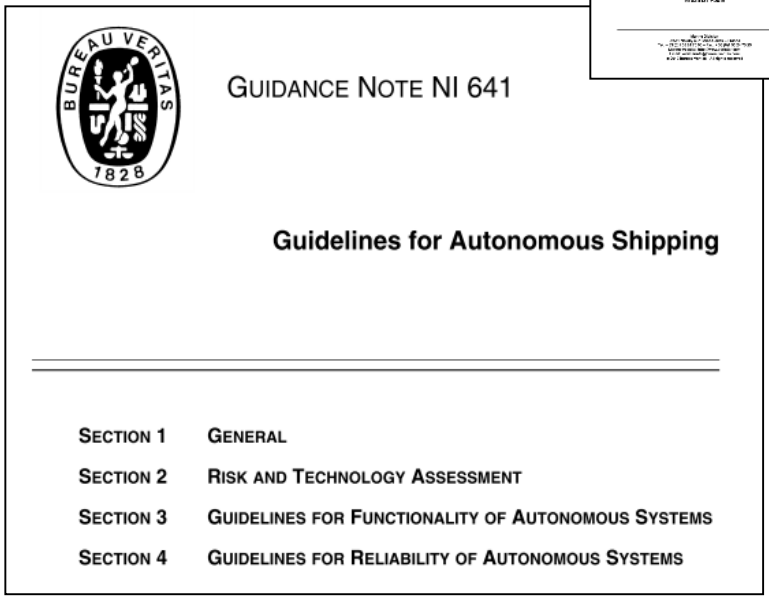
Minimum level of functionality for essential systems

Goal based recommendations

Reliability of autonomous systems

Recommendations on design and **level of performance**

Quality assurance methodology


GUIDANCE NOTE NI 641

Guidelines for Autonomous Shipping

SECTION 1	GENERAL
SECTION 2	RISK AND TECHNOLOGY ASSESSMENT
SECTION 3	GUIDELINES FOR FUNCTIONALITY OF AUTONOMOUS SYSTEMS
SECTION 4	GUIDELINES FOR RELIABILITY OF AUTONOMOUS SYSTEMS

NI 641 – DRAFT APRIL 2019

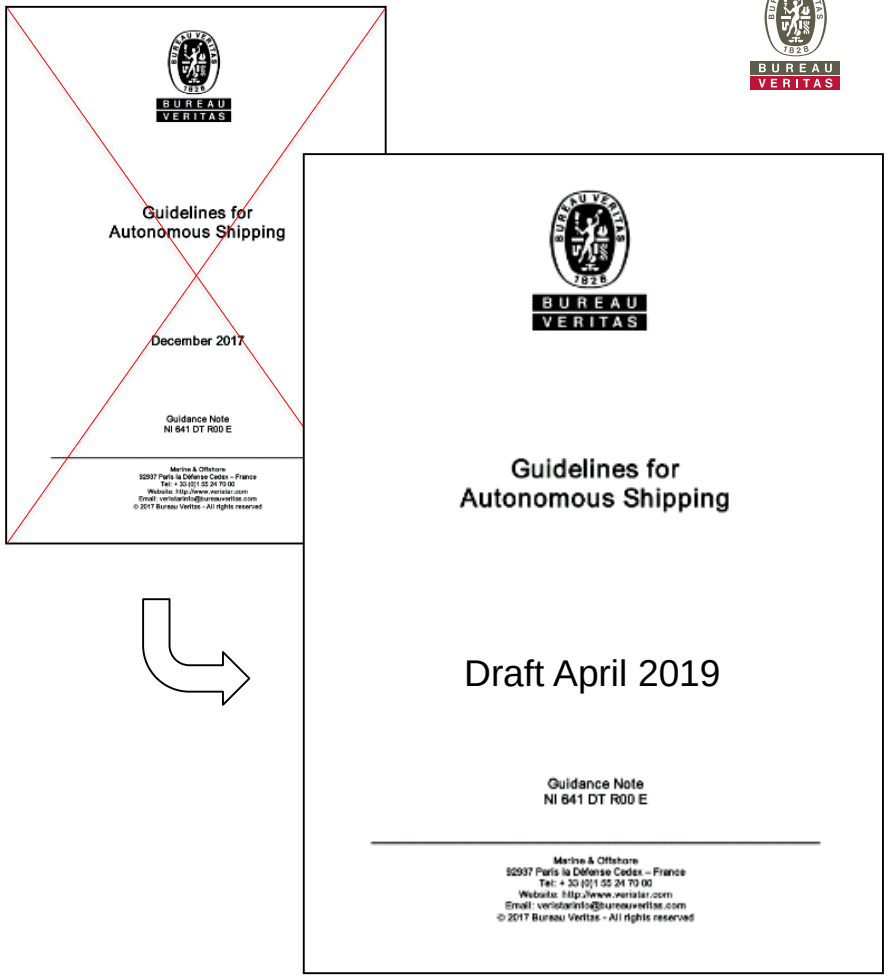
Update of NI 641

taking account
more than 140 comments
from clients, manufacturers, flags, BV network

DRAFT April 2019

shared **internally** and **externally** for comments

Tentative **date for publication : Q3 2019**



NI 641 – SCOPE

Back to Index

INCLUDED

- **Design and operations of smart ships** and their associated **remote control centres** (if any)
- **small units** not more excluded

EXCLUDED

- exclusion limited to **underwater vehicles** and **non-manoeuvring units**, such as drifting buoys used for scientific researches

1.2.2 This Guidance Note is mainly focused on surface units which may be considered as a ship by the authorities (e.g. Maritime Autonomous Surface Ships of 500 GT or more). This excludes small ships (typically length less than 20 m) and unmanned underwater vehicles.

December 2017

1.2.2 This Guidance Note is mainly focused on surface propelled units. This excludes underwater vehicles and non-manoeuvring units, such as drifting buoys used for scientific research.

1.2.3 The recommendations of this guidance note are related to the design and operations of smarts ships and their associated remote control centres (if any) only. Sites, devices, and procedures for launching of smart ships are out of scope.

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NI 641 – WORDING

- **Remote Control Centre (RCC)**
  - the Remote Control Centre (RCC) is outside the vessel and can be onshore or on another ship or offshore unit
- **Crew** --> aboard
- **Operators** --> in the RCC

Remote Control: control of an operation at a point distant from the controlled device, using the transmission of information by telecommunications techniques. Smart ships may be remotely controlled from a control centre located onshore or on another ship or offshore unit.

Crew: all persons carried aboard the ship to provide navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide services for other persons aboard (IMO Resolution MSC.266(84)).

Operators: all persons in the remote control centre to provide remotely navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide remotely services for other persons aboard.

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NI 641 – DOCUMENTS TO BE SUBMITTED

Back to Index

- **List of documents to be submitted**

1.7.1 At the request of the designer, shipyard, manufacturer and/or owner, the Society may review the design of a smart ship according to the content of this Guidance Note.

1.7.2 For this purpose, the documents that should be submitted in the scope of this review are listed in Tab 1.

Topic	Plans and documents to be submitted
Classification	Plans and documents to be submitted according to Society Rules in the scope of the classification of the ship and relevant to the service notation applied for
Additional class notations	Plans and documents to be submitted according to Society Rules in the scope of the additional class notations as specified in this Guidance Note, see Sec 3, [2.3.1], Sec 3, [4.3.1], Sec 3, [5.3.1] and Sec 4, [7.1.1]
Operating limits	Details of parameters to which the crew or operators must refer for the control of the vessel, see [2.3]
Identification	Details of provisions for identification, see [2.4]
Implementation	Details of provisions for implementation, see [2.5]
Interactions	Details of provisions for interactions, see [2.6]
Automation systems	Detailed specification of all automation systems, including: • Specification of the Navigation system, see Sec 3, [2] • Specification of the Communication network and system, see Sec 3, [3] • Specification of the Machinery system, see Sec 3, [4] • Specification of the Cargo management system, see Sec 3, [5] • Specification of the Passenger management system, see Sec 3, [6] • Specification of the Remote Control Centre, see Sec 3, [7] These specifications should clearly specify for each function the distribution of roles and responsibilities between the human and the system, see [2.7] and Sec 2, [3.4.1]
Risk assessment	Detailed risk assessment report including: • Groups of functions considered, see Sec 2, [2.2] • List of hazards considered, see Sec 2, [2.3] • Risk analysis outcome, see Sec 2, [2.4] • Risk Control Options considered, see Sec 2, [2.5]
Technology assessment	Detailed technology assessment report, if applicable, see Sec 2, [3]
Reliability	Details of provisions for improving the reliability of systems including: • General system design, see Sec 4, [2] • Human machine interface, see Sec 4, [3] • Network and communication, see Sec 4, [4] • Software quality assurance, see Sec 4, [5] • Data quality assurance, see Sec 4, [6] • Cybersecurity, see Sec 4, [7]
Testing	Detailed tests specifications and reports, including: • Software tests, see Sec 4, [8.1] • Simulation tests, see Sec 4, [8.2] • Full scale tests, see Sec 4, [8.3] All tests reports should include the targeted objective, the followed procedure, the expected results and the outcome achieved
Pollution	Details of provisions for preventing pollution, see [3.4]
Recycling	Details of provisions for recycling, see [3.8]

NI 641 – CHARACTERISATION OF SHIPS

Any ship should be characterised by:

- a **global degree of automation GAx** (x from 0 to 4)
- a **global degree of direct control GDCy** (y from 0 to 3)
- a **global degree of remote control GRCz** (z from 0 to 3)
- a **navigation notation**

1.8.1 Any ship covered by the present Guidance Note should be characterised by:

- a global degree of automation GAx (x from 0 to 4), see [1.9]
- a global degree of direct control GDCy (y from 0 to 3), see [1.10]
- a global degree of remote control GRCz (z from 0 to 3), see [1.10]
- a navigation notation, see [1.11]

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NI 641 – DEGREES OF AUTOMATION

- **Degrees of automation**

  degree of decision making (authority) deferred from the human to the system.

1.9.3 A degree of automation Ax (x from 0 to 4) should be defined for each automation system prior to any assessment of a smart ship.

1.9.4 A global degree of automation GAx (x from 0 to 4) of a smart ship should be defined considering the lowest degree of automation of main systems covering essential services involved in the operations of the ship (see Sec 2, [2.2.1] and Sec 3).

1.9.5 Several different degrees of automation could be considered for the duration of a single voyage.

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NI 641 – DEGREES OF AUTOMATION

Back to Index

Degree of automation (1)		Manned	Method of control	Authority to make decisions	Actions initiated by
A0	Human operated	Yes	Automated or manual operations are under human control	Human	Human
A1	Human directed	Yes/No	Decision support Human makes decisions and actions	Human	Human
A2	Human delegated	Yes/No	Human must confirm decisions	Human	System
A3	Human supervised	Yes/No	System is not expecting confirmation Human is always informed of the decisions and actions	Software	System
A4	Full automation	Yes/No	System is not expecting confirmation Human is informed only in case of emergency	Software	System

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NI 641 – DEGREES OF CONTROL

- **Degrees of control**

  definition of degree of availability
  of crew or operators operating smart ships
  on-board or remotely outside the vessel

1.10.3 A degree of direct control DCy (y from 0 to 3) and remote control RCz (z from 0 to 3) should be defined for each automation system prior to any assessment of a smart ship.

1.10.4 A global degree of direct control GDCy (y from 0 to 3) and remote control GRCz (z from 0 to 3) of a smart ship should be defined according to the lowest degrees of direct control and remote control of main functions covering essential services involved in the operations of the ship (see Sec 2, [2.2.1] and Sec 3).

1.10.5 Several different degrees of control could be considered for the duration of a single voyage.

NI 641 – DEGREES OF CONTROL

Degree of control			Human presence	Location of control station
Direct control	DC0	No direct control	No crew available to monitor and control the system, nor to take control in case of warning or alert.	**(1)**
	DC1	Available direct control	Crew available aboard, ready to take control in case of warning or alert But they may be not at the control station	Aboard
	DC2	Discontinuous direct control	Monitoring may be discontinuous during a short period Crew always available at the control station, ready to take control	Aboard
	DC3	Full direct control	System is actively monitored and controlled at any time	Aboard
Remote control	RC0	No remote control	No operator available to monitor and control remotely the system, nor to take control in case of warning or alert.	**(1)**
	RC1	Available remote control	Operators available in the RCC, ready to take control in case of warning or alert But they may be not at the remote control station	RCC
	RC2	Discontinuous remote control	Remote monitoring may be discontinuous during a short period Operators always available at the remote control station, ready to take control	RCC
	RC3	Full remote control	System is actively monitored and controlled remotely at any time	RCC

(1) See also [2.9.3]: it may have no any integrated control station

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NI 641 – CYBER SECURITY

Back to Index

- **Cyber security :** reference to
  - the **NR 659** “Rules on Cyber Security for the Classification of Marine Units”
  - the additional class notation **CYBER SECURE**

7.1.1 The computer based systems and networks should be compliant with the applicable requirements related to the assignment of the additional class notation **CYBER SECURE** from Society Rule Note NR659, Cyber Security for the Classification of Marine Units.

7.1.2 The applicable requirements related to the assignment of this additional class notation may be adjusted to the satisfaction of the Society according to the results of the risk and technology assessment, the degree of automation, the degree of direct control and remote control, the navigation notation, the operating limits, the possibility of external rescue, etc.

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1/ NI 641

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for the use of
Maritime **A**utonomous **S**urface **S**hip (MASS)

3/ ISO

TC 8 / WG 10 / AWI 23860
Terminology related to automation of MASS

4/ EU SMART PROJECTS

BV M&O DV involvement

IMO – RSE FOR THE USE OF MASS

MSC 98 (06/2017) agreed to include in its 2018-2019 biennial agenda the **Regulatory Scoping Exercise (RSE)** for the use of **Maritime Autonomous Surface Ships (MASS)**, with a **target completion year of 2020.**

MSC 99 (05/2018) defined **the aim and objective**, the **preliminary definition of MASS and degrees of autonomy**, the **list of mandatory instruments** to be considered and the **methodology for the exercise**

Correspondence Group (06/2018 – 09/2018)
tested the framework and methodology

MSC 100 Working Group (12/2018)
finalized the framework, including the **template** and the **plan and method of work**.

MSC 101 Working Group (06/2019)
developed an **interim guidelines** for **MASS trials,** with high level objectives following a goal-based approach

IMO RSE – LIST OF INSTRUMENTS AND VOLUNTEERING MEMBERS

Instrument	Chapter/ Section	Degree of autonomy	Member State preparing the initial review	Supporting/assisting
SOLAS 1974				
	Chapter II-1	All	France	Sweden, Iran (Islamic Republic of), China
	Chapter II-2 (1)	All	Japan	China, IACS
	Chapter III	All	Netherlands	Belgium , China
	Chapter IV	All	Turkey	China, Japan
	Chapter V	All	China	Denmark, Japan, Singapore
	Chapter VI (2)	All	Japan	China
	Chapter VII (3)	All	Japan	China
	Chapter IX	All	Norway	China, Republic of Korea, Russian Fed., Nigeria
	Chapter XI-1 (4)	All	Finland	China
	Chapter XI-2 (5)	All	Finland	China
	Chapter XIV (6)	All	Finland	

Instrument	Chapter/ Section	Degree of autonomy	Member State preparing the initial review	Supporting/assisting
STCW 1978 and STCW Code		All	United States	Japan, New Zealand, Republic of Korea, Cyprus Russian Fed.,China,Spain
STCW-F 1995		All	Japan	New Zealand , Spain
COLREG 1972		All	Marshall Islands	China, Japan, Singapore, USA, Spain, Sweden
CSC 1972		All	Japan	Finland
LL 1966		All	India	China, Liberia
LL PROT 1988		All	India	Liberia
SAR 1979		All	Spain, France	Turkey
SPACE STP 1973				
STP 1971				
TONNAGE 1969			Liberia	

BV M&O fully involved with French Flag
in the review of **SOLAS Chapter II-1**

(1) including International Code for Fire Safety Systems (FSS Code)
International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code)

(2) including International Maritime Solid Bulk Cargoes Code (IMSBC Code)
Code of Safe Practice for Cargo Stowage and Securing (CSS Code)
International Code for the Safe Carriage of Grain in Bulk Parts A & B

(3) including International Maritime Dangerous Goods Code (IMDG Code)
International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)
International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)

(4) including Code for Recognized Organizations (RO Code)
International Code on the Enhanced Program of Inspections during Surveys of Bulk and oil Tankers, 2001 (2011 ESP Code)
Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code)

(5) including International Ship and Port Facility Security Code (ISPS Code)

(6) including International Code for Ships Operating in Polar Waters (Polar Code)

IMO RSE – NEXT STEPS

Jan → Apr	Initial Review
May → June	Comments Initial Review
July	Results Initial Review
02/09 → 06/09	Intersessional MSC Working Group in London
Sep → Oct	Step 2
Nov	Comments Step 2
Dec → Jan 2020	Results Step 2
May 2020	MSC 102

BV M&O fully involved with French Flag in the review of **SOLAS Chapter II-1**

ISO/AWI 23860 ed.1- id.77186

Ships and marine technology -- Terminology related to automation of Maritime Autonomous Surface Ships (MASS)

ISO/TC 8/WG 10

20.00

Since 2019-02-14

Registered for 2 months

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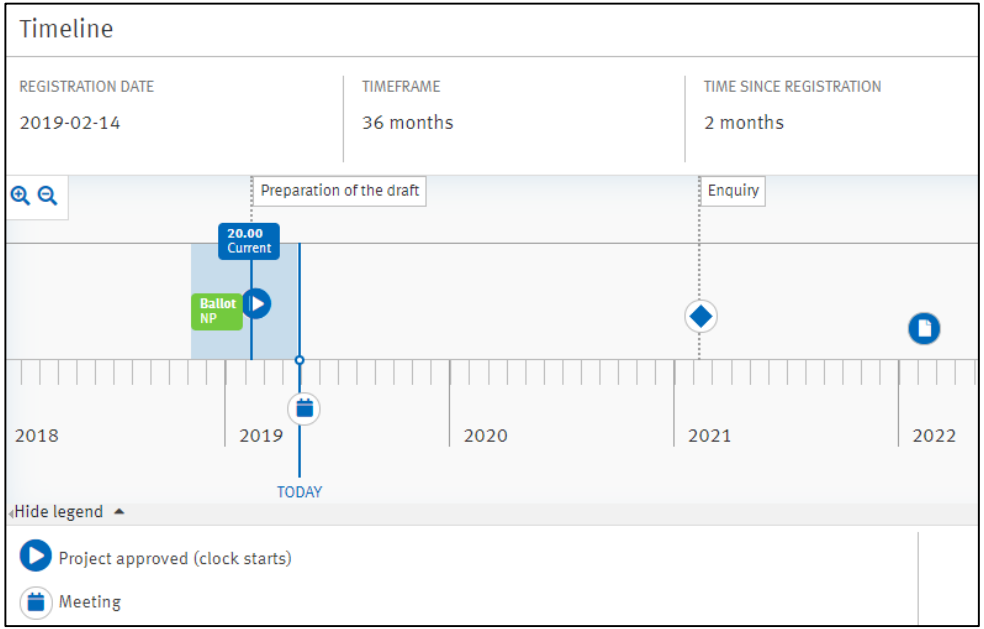
ISO TC 8 / WG 10 / AWI 23860
TERMINOLOGY RELATED TO AUTOMATION OF MASS

ISO/AWI 23860 ed.1- id.77186 Ships and marine technology -- Terminology related to automation of Maritime Autonomous Surface Ships (MASS)	ISO/TC 8/WG 10 20.00 Since 2019-02-14 Registered for 1 month
ISO/PWI 23816 ed.1- id.77042 Ships and marine technology -- Technical specifications of IPv6 based ship-network	ISO/TC 8/WG 10 00.00 Since 2018-10-22
ISO/PWI 23809 ed.1- id.77041 Ships and marine technology -- Technical specifications of smart communication gateway	ISO/TC 8/WG 10 00.00 Since 2018-10-22
ISO/PWI 23807 ed.1- id.77040 Ships and marine technology -- Ship-shore data communication	ISO/TC 8/WG 10 00.00 Since 2018-10-22



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EU H2020 PROJECT – NOVIMAR

Project **NOVIMAR:** develop a new waterborne transport concept called the **Vessel Train.** https://vimeo.com/263869758

A **Lead Vessel**, followed by a series of lowly manned, digitally connected **Follower Vessels.**

This concept will **reduce operational costs** and increase economies of scale due to better usage of existing infrastructure.

22 partners: logistic operators, industry, public bodies and research organisations from seven EU & two associated countries.

BV M&O involved in **regulations**, **safety, risks analysis** and **cybersecurity** work packages.

Duration: **48 months** (June 2017 → May 2021)

EU H2020 PROJECT – AUTOSHIP

Project **AUTOSHIP:** smart, green and integrated transport

Scope: **develop and demonstrate to TRL7 (*) a fully autonomous vessel** within a realistic environment

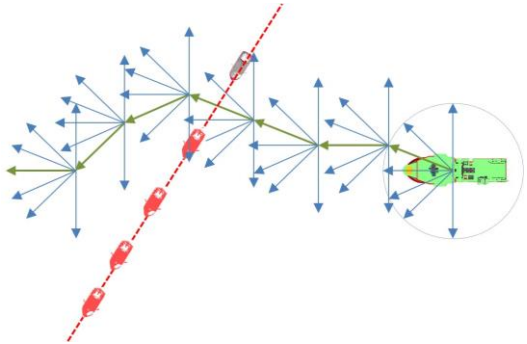
Focus on first adopters**: inland waterways, short sea shipping, ferries coastal operations and urban water transport**

BV M&O involved in **regulations**, **safety, risks analysis** and **cybersecurity** work packages.

Duration: **36 months** (June 2019 → May 2022)

(*) TRL7 = Technology Readiness Level 7 = System prototype demonstration in operational environment

DUTCH AUTONOMOUS SHIPPING JIP



- **Dutch research & innovation project**
  focused on autonomous operations at sea (2017-2019)
  - 17 consortium partners
  - Detailed man-to-machine task-transfer study
- **Full scale nautical scenario trials**
  (11 runs) in March 2019 in North Sea (Dutch national waters)
  - CTV SeaZip 3 (Damen FCS 2610, BV class) outfitted with collision avoidance technology
- **Autonomous navigation system** (connected to autopilot and machinery control system)

Thank you
for your attention

Questions
& Answers