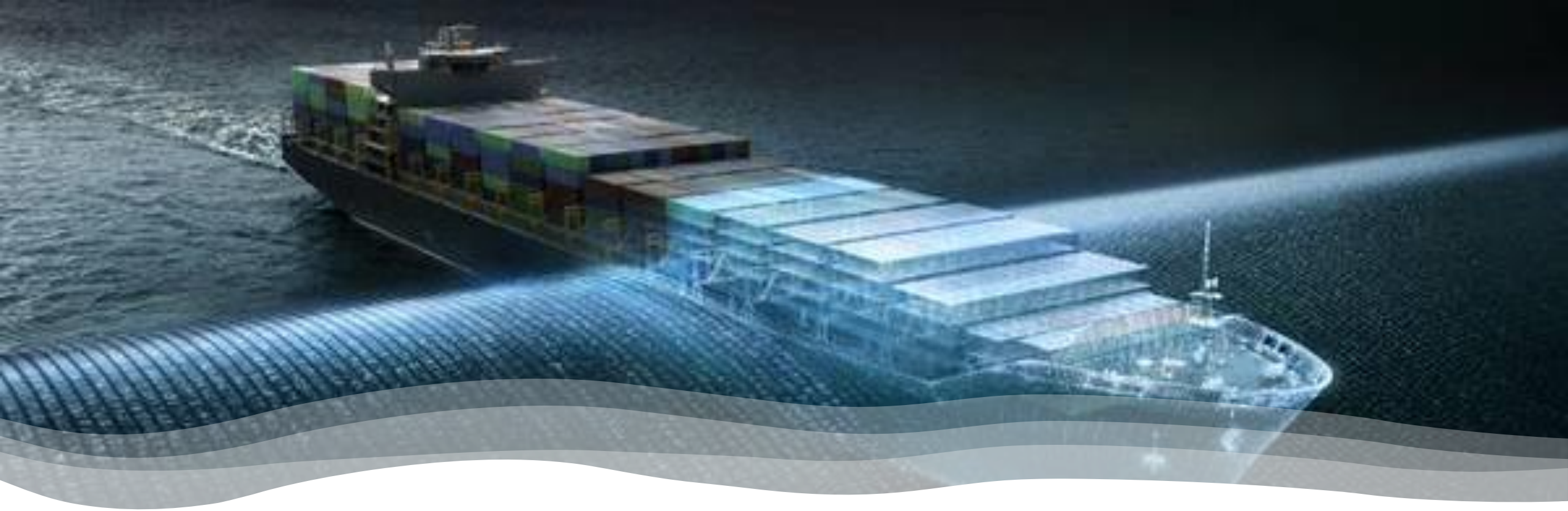

Autonomous Ships:
Terms of reference for rule development

International Conference on MASS – ICMASS 2023
Rotterdam, Netherlands
November 8th , 2023

Capt. Marko Rahikainen
Director of Regulatory Affairs, One Sea Association

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Clear and

common terminology

is urgently needed to

- Facilitate the discussion,
- Ensure cross modality application,
- Create a seamless transport chain.

Goal of technology

Support human strengths with the capabilities of technology.

Combining the strengths of humans and technology

Human strengths

- Handling of uncertainty
- Applying knowledge and experience
- Creative problem-solving
- Human judgement

Machine strengths

- Continuity, objectivity
- Repeatability and consistency
- Very slow and very fast occurring events
- Machine does not get tired and does not forget

Role of technology

Technology doesn’t relive the master of any duties or responsibilities

From a technological point of view the location of the master is irrelevant

The role of a master

Master means the person having command of a ship

(UNCLOS art.94.4(b), STCW Ch I/1.3)

Photo: www.seamanmemories.com

The role of a master

To ensure that watchkeeping arrangements and composition are adequate for maintaining a proper lookout, safe navigational or cargo watch.

UNCLOS art.94.3(a) and 4(b)
STCW Convention & Codes Ch VIII

Photo: www.seamanmemories.com

Masters' authority

The master of the ship takes or executes any decision which, in the master's professional judgement, is necessary

(SOLAS Ch V/34-1 and Ch XI-2/8)

Photo: www.seamanmemories.com

Masters' discretion

A task may be performed by a crewmember or a system

A task may be delegated, but the responsibility remains by the master to ensure it is properly executed

Photo: www.seamanmemories.com

Levels of Automation

0	**Basic automation**	Human controls the vessel manually or with the help of simple unit-automation (e.g. autopilot).	Human controls the vessel.
1	**Assisted operations**	The system assists in operations by automation of observations or controls but does not make the connection of these two by the system. (e.g. DP systems)	Hands-on, eyes-on, mind-on
2	**Partial automation**	Automatic operation of at least one full function/operational mode. System monitors the actual situation and possibly executes actions to mitigate risks while keeping the operator informed. Operator may approve of action.	Hands-off (sometimes), eyes-on, mind-on
3	**Conditional automation**	Automatic operation of at least one full function/operational mode. System suggestions are executed automatically. In good conditions human tasks could be replaced by a machine for a short (relative to the situation) period.	Hands-off, eyes-off (sometimes), mind-on
4	**High automation**	Automatic operation of at least one full function/operational mode. System suggestions are executed automatically. Human tasks (those automated) are executed by a machine to high extent. Machine alerts human if situation is unclear.	Hands-off, eyes-off, mind-off (sometimes)
5	**Autonomous**	Fully autonomous operation of at least one full function/operational mode. Human operator is not needed in those functions/operational models which are automated.	Hands-off, eyes-off, mind-off = human-off

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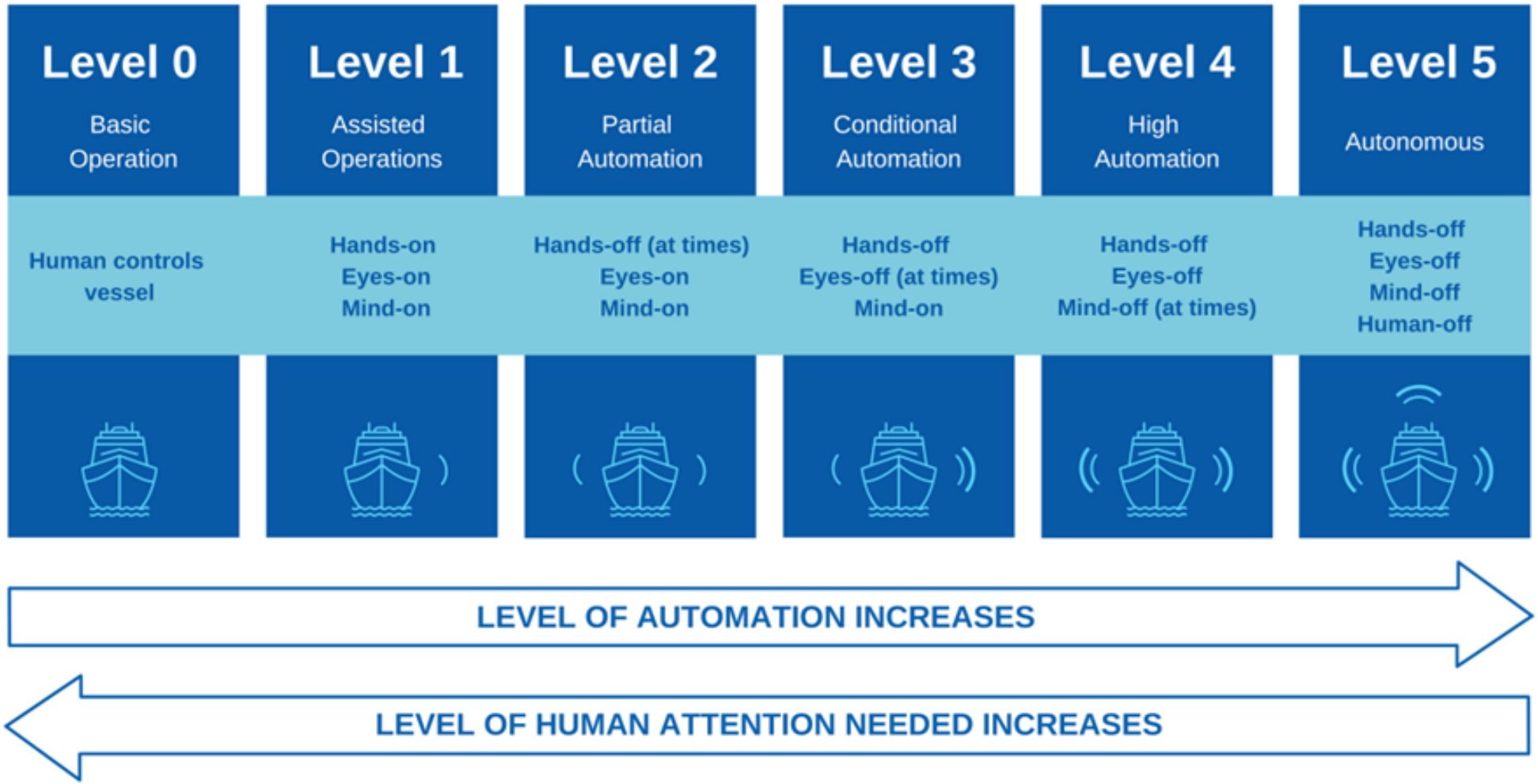

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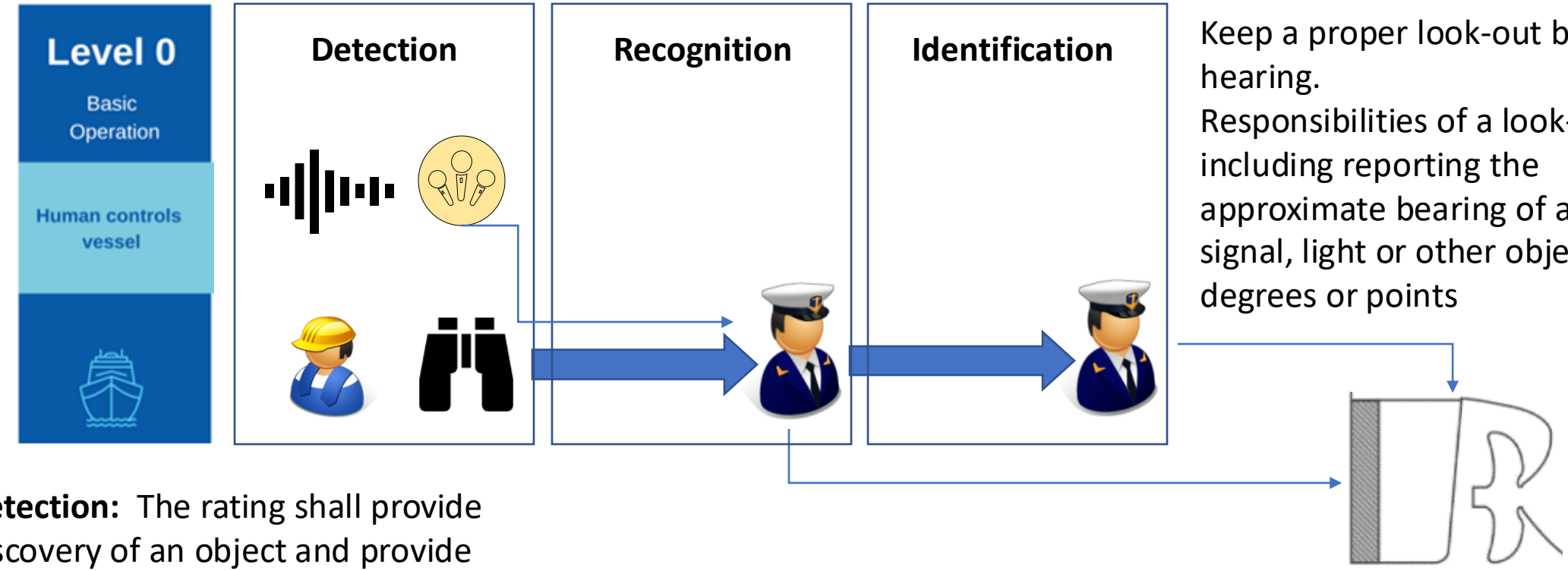
LOOKOUT

A proper lookout shall always maintain a continuous state of vigilance by sight and hearing, as well as by all other available means, with regard to any significant change in the operating environment.

Lookout
Rating - (Person designated as “lookout”)

STCW Convention - Regulation I/1.13 - Rating means a member of the ship’s crew other than the master or an officer.

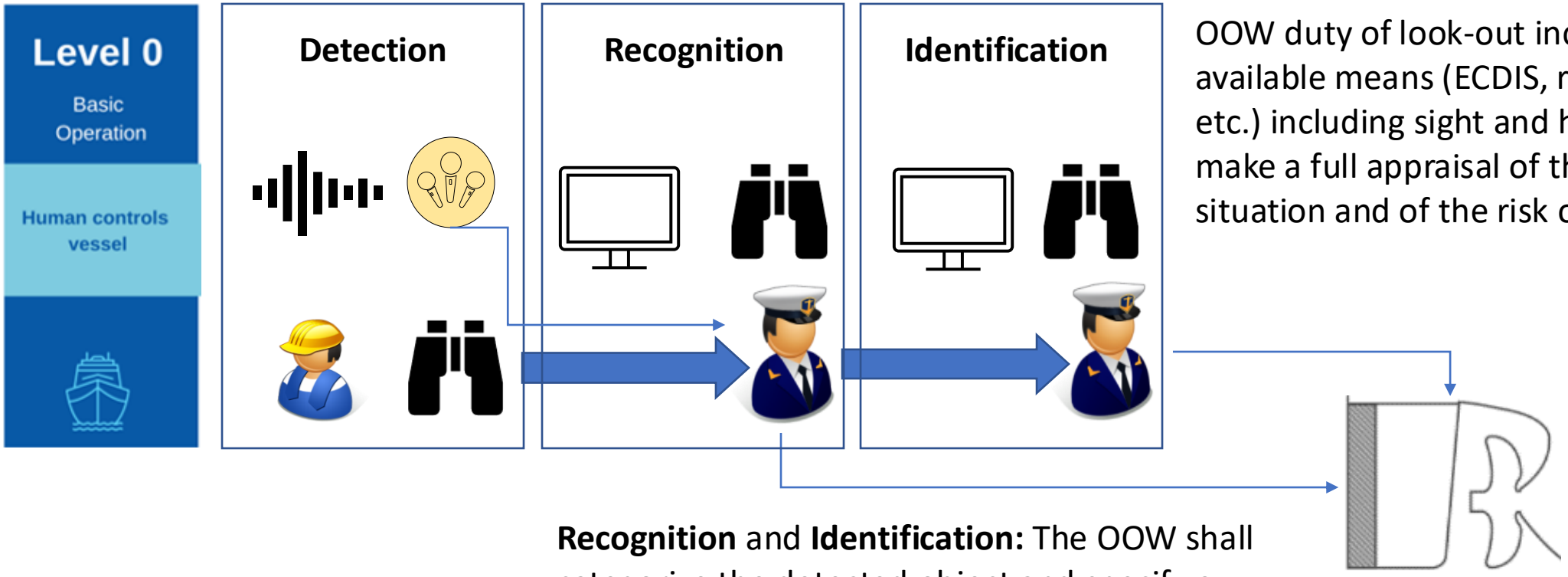


Keep a proper look-out by sight and hearing.
Responsibilities of a look-out, including reporting the approximate bearing of a sound signal, light or other object in degrees or points

Detection: The rating shall provide discovery of an object and provide this information for OOW.

Lookout
The Officer of The Watch (OOW)

STCW Code Part 4-1 – 13 - The officer in charge of the navigational watch is the master's representative and is primarily responsible at all times for the safe navigation of the ship and for complying with COLREG.



OOW duty of look-out includes all available means (ECDIS, radar, AIS etc.) including sight and hearing to make a full appraisal of the situation and of the risk of collision.

Recognition and **Identification:** The OOW shall categorize the detected object and specify a unique identity of a recognized object needed to decide whether and how to react to the identified object.

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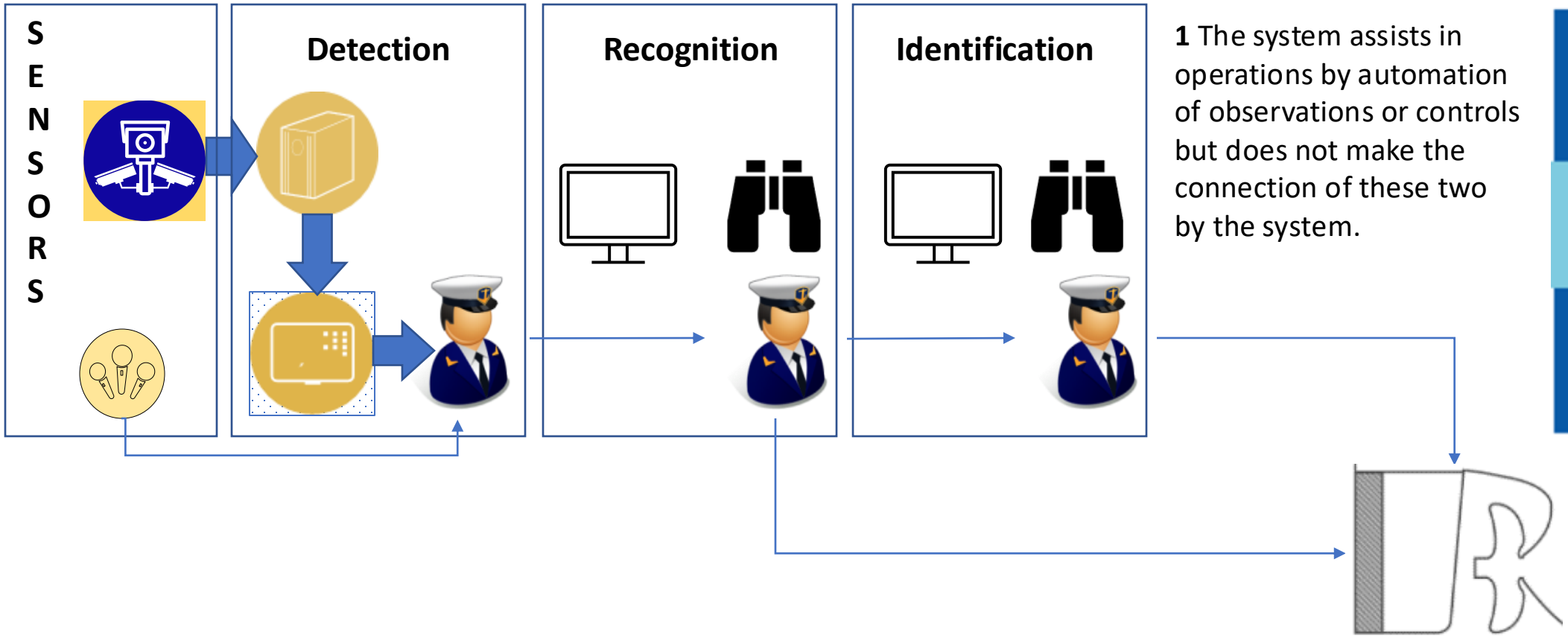
AUTOMATED LOOKOUT

Improved safety, accuracy and reliability as well as improved seafarer working conditions and welfare.

Automated Lookout System (ALS)

Goal 1 Detection: The goal of the detection function is to provide discovery of an object and provide this information for the recognition function.

1 Assisted operations

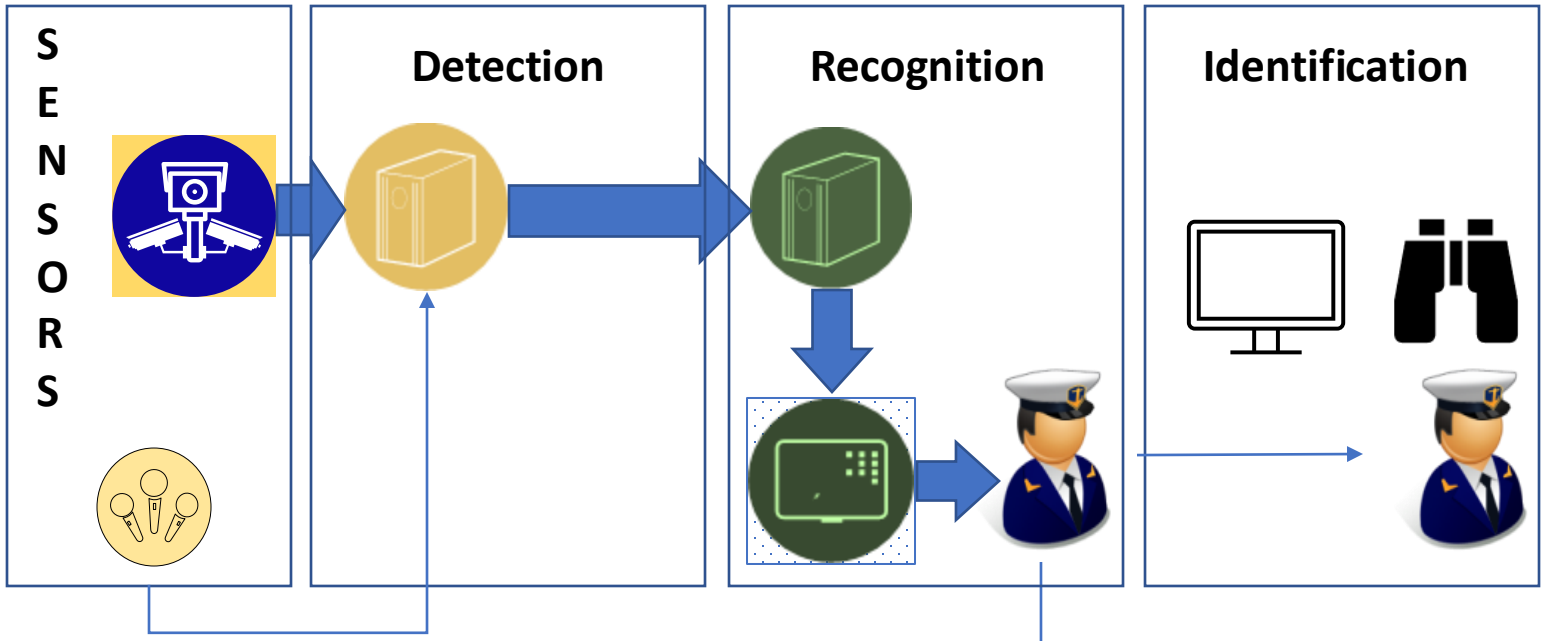


1 The system assists in operations by automation of observations or controls but does not make the connection of these two by the system.

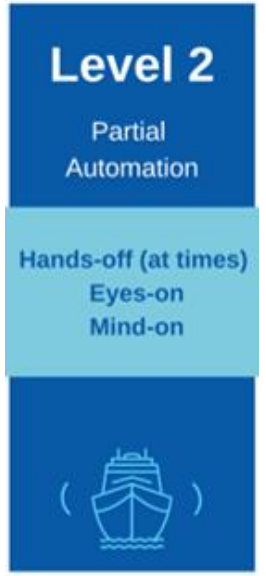
Automated Lookout Systems (ALS)

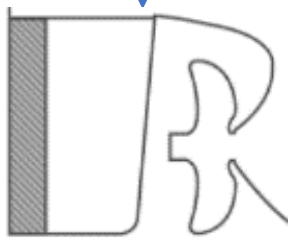
Goal 2 Recognition: The recognition function shall categorize the detected object and provide this information to the identification function.

2 Partial automation



2 Automatic operation of at least one full function/operational mode. System monitors the actual situation and possibly executes actions to mitigate risks while keeping the operator informed. Operator may approve of action.

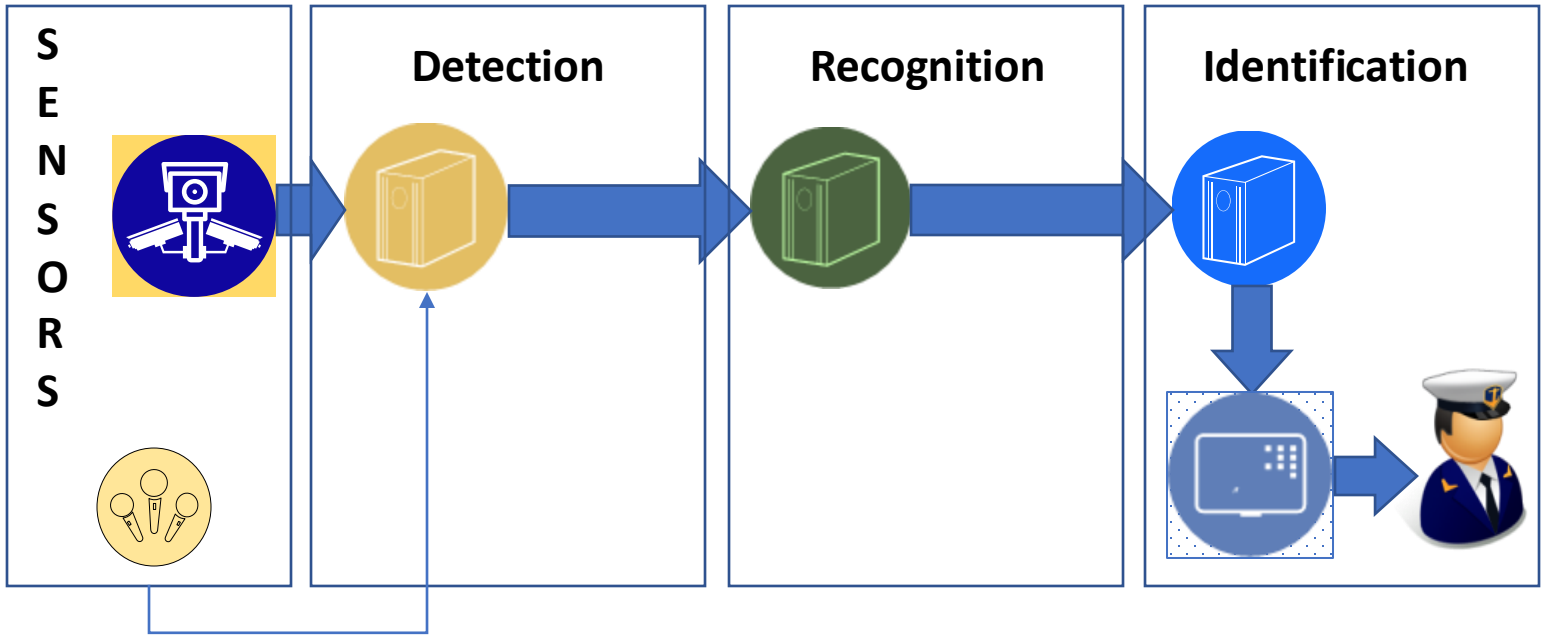




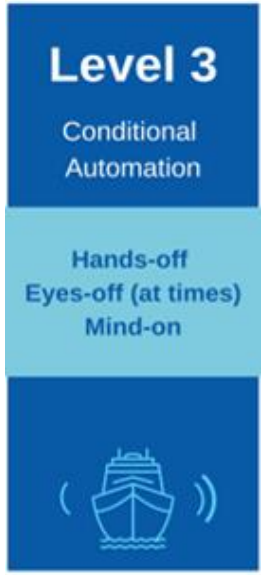
Automated Lookout Systems (ALS)

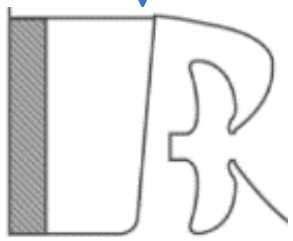
Goal 3 Identification: The identification function shall specify a unique identity of a recognized object needed to decide whether and how to react to the identified object.

3 Conditional automation



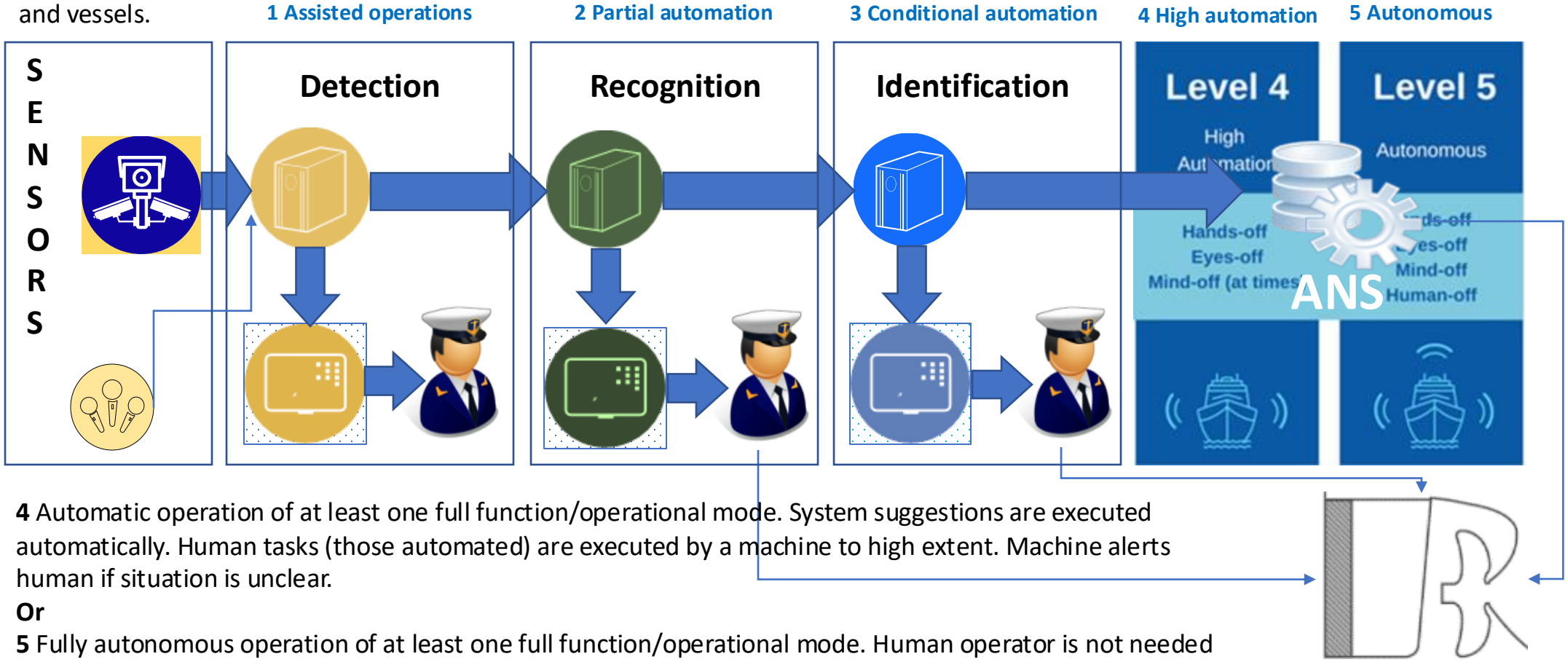
3 Automatic operation of at least one full function/operational mode. System suggestions are executed automatically. In good conditions human tasks could be replaced by a machine for a short (relative to the situation) period.





Automated Lookout System (ALS)

Goal - to continuously monitor the ship's surroundings, when the ship is underway or at anchor, to detect, recognize and identify any objects and lights on the surface of the sea in the ship's vicinity relevant to the safety of persons and the ship as well as other ships and vessels.



4 Automatic operation of at least one full function/operational mode. System suggestions are executed automatically. Human tasks (those automated) are executed by a machine to high extent. Machine alerts human if situation is unclear.

Or

5 Fully autonomous operation of at least one full function/operational mode. Human operator is not needed in those functions/operational models which are automated.

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REMOTE SERVICES

Remote **O**perations **C**entre means a location remote from the MASS that can operate some or all aspects of the functions of the MASS

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Remote Master / Operator

Bridge Resource Management principles should be adhered to and obligations and tasks executed as on-board

Should not be considered as a seafarer

IMO Degrees of Autonomy

Degree one: ***Ship with automated processes and decision support:*** Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

Degree two: ***Remotely controlled ship with seafarers on board:*** The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

Degree three: ***Remotely controlled ship without seafarers on board:*** The ship is controlled and operated from another location. There are no seafarers on board.

Degree four: ***Fully autonomous ship:*** The operating system of the ship is able to make decisions and determine actions by itself.

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Crewing of MASS

The number of qualified and experienced seafarers necessary

Minimum crew is the flag States sovereign right and should remain under the jurisdiction of the flag State

(A.1047(27))

Crewing and persons onboard

Master

Persons onboard

Crewed - The ship is having seafarers onboard with appropriate qualifications (Certificates of Competency (CoC)) to attend and operate the onboard systems controlling the ship. (Explanation: This is officers and/or ratings)

Periodically Crewed - The ship may have a limited number of seafarers onboard with appropriate qualifications (CoC) to periodically attend and operate the onboard systems controlling the ship. Remote controlled and attended or autonomous systems operate the onboard systems controlling the ship, when not attended by the onboard crew.

Un-Crewed - The ship may have seafarers onboard required to have training according to their safety responsibilities but not required to have CoC's according to STWC requirements. (Explanation: This is seafarers having e.g., Basic Safety Training, rescue raft commander, evacuation training, fire fighting)

Crewless - The ship does not have any seafarers onboard. (There can be max. 12 persons onboard in international traffic

Level of Automation	Degree of Autonomy
0	IMO 1
1	IMO 2
2	IMO 2
3	IMO 3
4	IMO 4
5	IMO 4

ROC

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Level of

Remote Interaction

1. Monitoring
   read only information
2. Supervision
   high-level commands
3. Intervention
   detailed commands
4. Direct Control
   direct commands

Automation, Autonomy and Remote Interaction

Level of Automation 0

Level of Automation 1

Remote
1 Monitoring or 2 Supervision

Level of Automation 2

Level of Automation 3

Level of Automation 4

Remote
1 Monitoring or;
2 Supervision or;
3 Intervention or;
4 Direct Control

According to crewing

Remote
4 Direct Control

Level of Automation 5

Remote
3 Intervention

Degree of Autonomy IMO 1	Degree of Autonomy IMO 2	Degree of Autonomy IMO 3	Degree of Autonomy IMO 4
ROC			

Remote Interaction levels

1. Monitoring - Allows read only information.
2. Supervision - In addition to ***Monitoring,*** allows high-level commands to on-board system(s).
3. Intervention - In addition to ***Supervising***, allows detailed commands to on-board system(s).
4. Direct Control - In addition to ***Intervention***, allows direct commands to low level control loop(s).

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ROC Safety

ROC Level 1 - not safety critical
ROC Level 2 - safety support
ROC Level 3 - safety critical

ISO 22237 - Data Centre
ISO 11064 - Control Centre
IEC 62443 - Cybersecurity

Remote Operations Center Levels

Level of Automation 0

ROC Level 1 - Availability medium, ROC is not safety critical - Crewed ship

Level of Automation 1

Level of Automation 2

Level of Automation 3

Level of Automation 4

Level of Automation 5

ROC Level 1

ROC Level 1

ROC level 3 - Availability very high, ROC is safety critical - Un-Crewed/crewless Ship

ROC Level 3

ROC level 2 - Availability high, ROC is safety support - Un-crewed/crewless Ship

ROC Level 2

Degree of Autonomy IMO 1

Degree of Autonomy IMO 2

Degree of Autonomy IMO 3

Degree of Autonomy IMO 4

ROC

ISO 22237
Data Center

ISO 11064
Control Centre

IEC 62443
Cybersecurity

Automation, Autonomy and Remote Services

	Remote 1 Monitoring	Remote 1+2 Supervision	Remote 1+2+3+4 Direct Control	Remote 1+2+3 Intervention
Level of Automation 0				
Level of Automation 1	2 / 1	2 / 1		
Level of Automation 2	4 / 1	4 / 1		
Level of Automation 3	4 / 1	4 / 1	4 / 3	
Level of Automation 4	4 / 1	4 / 1	4 / 3	
Level of Automation 5				3 / 2
Degree of Autonomy	IMO 1	IMO 2	IMO 3	IMO 4
ROC				

ISO 22237
Data Center

ISO 11064
Control Centre

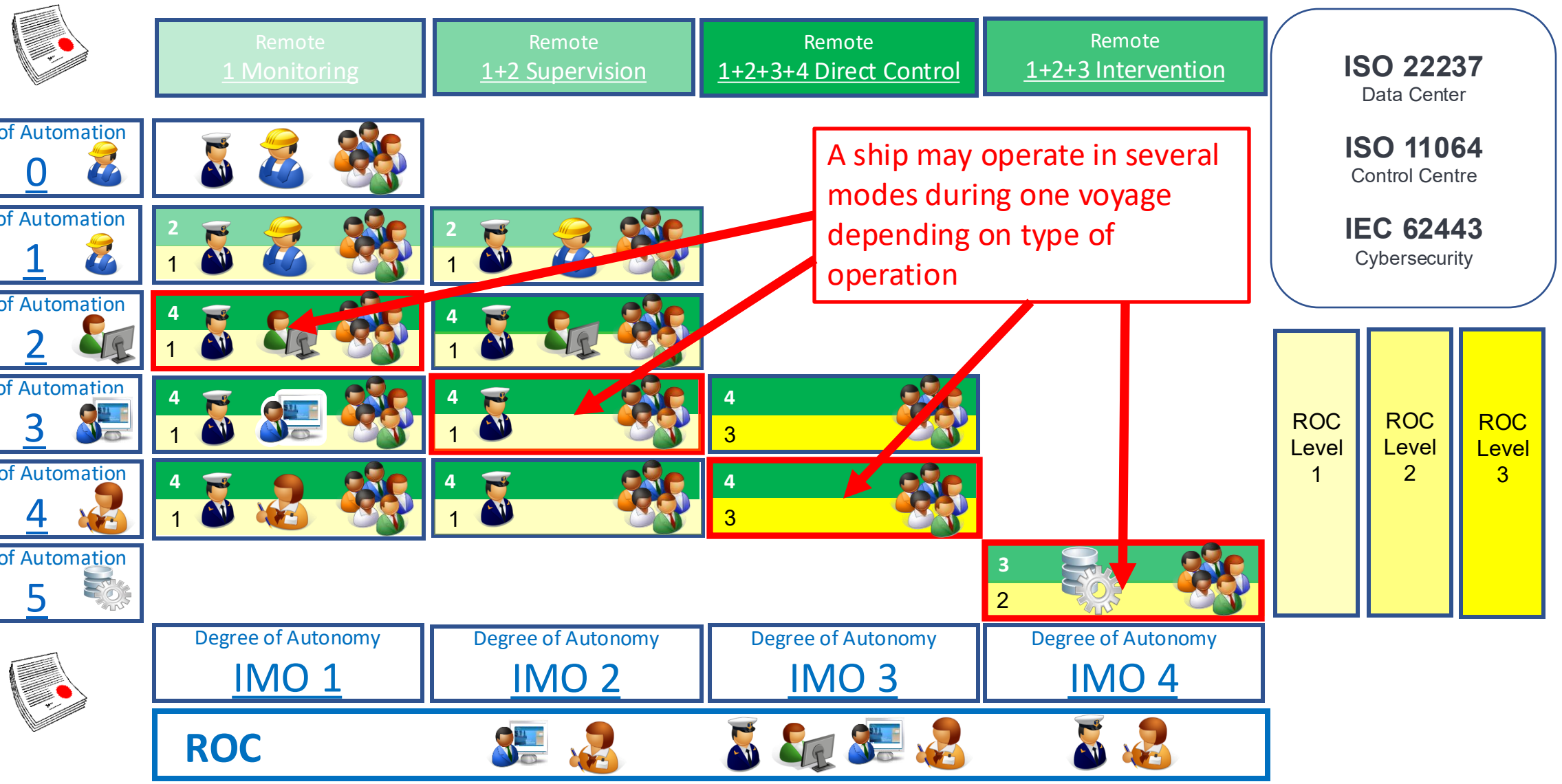
IEC 62443
Cybersecurity

ROC Level 1

ROC Level 2

ROC Level 3

Automation, Autonomy and Remote Services



The MASS Code

Reduced regulatory uncertainty on the way towards productization of automated functions which take over tasks from officers and crew engaged in ship operation.

Technology solutions are critical for the maritime industry to address inefficiencies across the entire supply chain.

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Status of a MASS

A ship is a system of systems

A MASS ship or system
is a SOLAS ship and
is a ship among existing ships
and technologies

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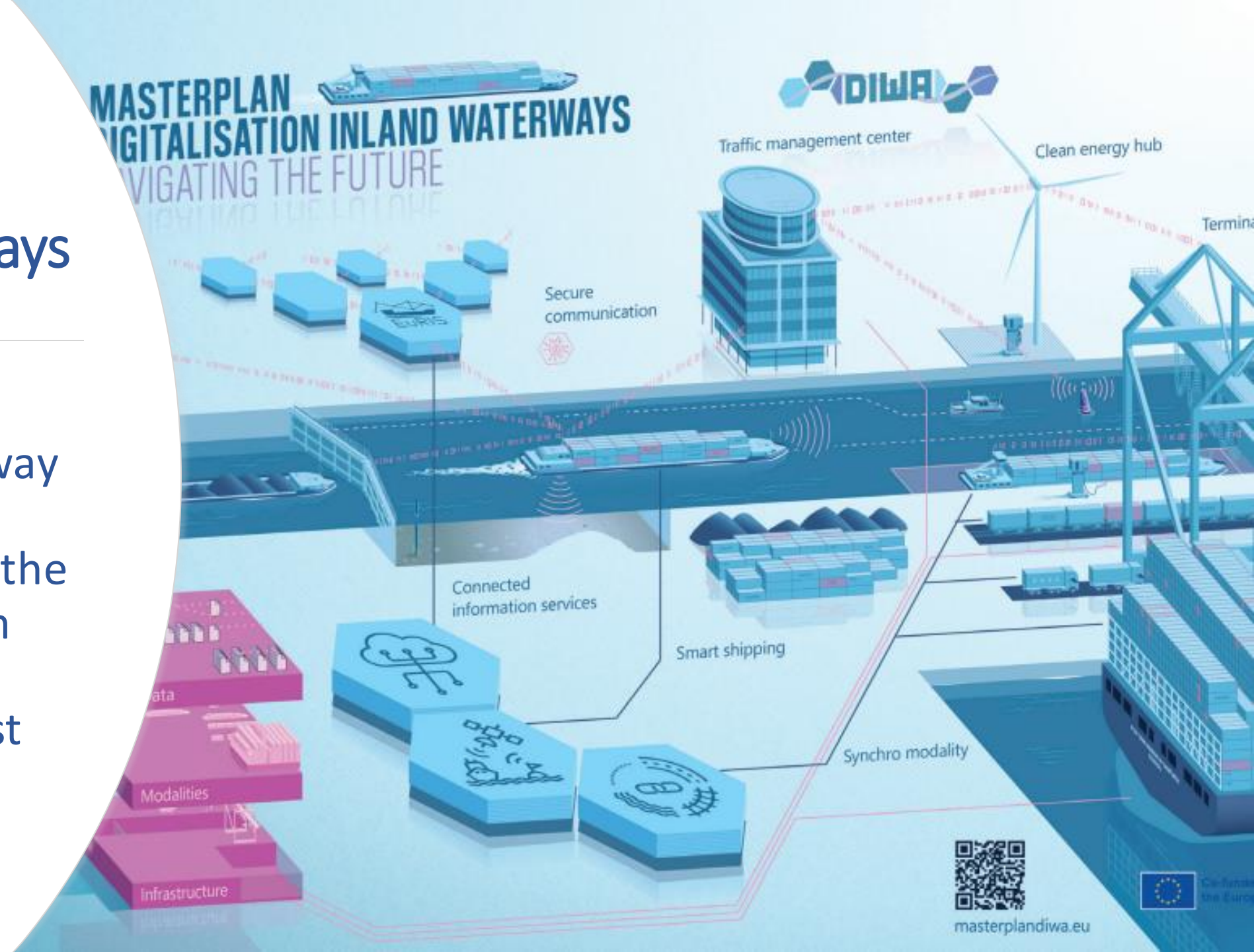
Main principles

of the MASS Code under development should be a:

- complementarity,
- holistic,
- technology neutral instrument.

Inland Waterways

A treaty between basically all waterway and shipping administrations of the central and Eastern European IWT grid has been struck last year



Permit to operate

Bi-lateral or multilateral agreements should be the first step to establish international remote or autonomous maritime transport

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There is a

lack of focus

in the discussions in the role of a regulator

- IMO is the regulator ensuring SAFETY
- The industry is the developer and solution manufacturer

Risk

The use of [automated and/or remotely controlled] security systems *should not endanger the security of any persons* or property on board or of the ship.

"…systems shall not prevent the effective physical security…., pose a *risk to persons*,"

… or Enabler

The use of [automated and/or remotely controlled] security systems shall be designed to ensure the safety of any persons or property on board or of the ship.

"…systems shall ensure the physical security …., ensure the safety of persons,"