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Integrated Maritime Autonomous Transport Systems

Kay Fjørtoft, SINTEF Ocean

Tony Haugen, Kongsberg Seatex

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ICMASS
International Conference on MASS

Trondheim, Norway - November 13th and 14th 2019 imat

Integrated Maritime Autonomous Transport Systems

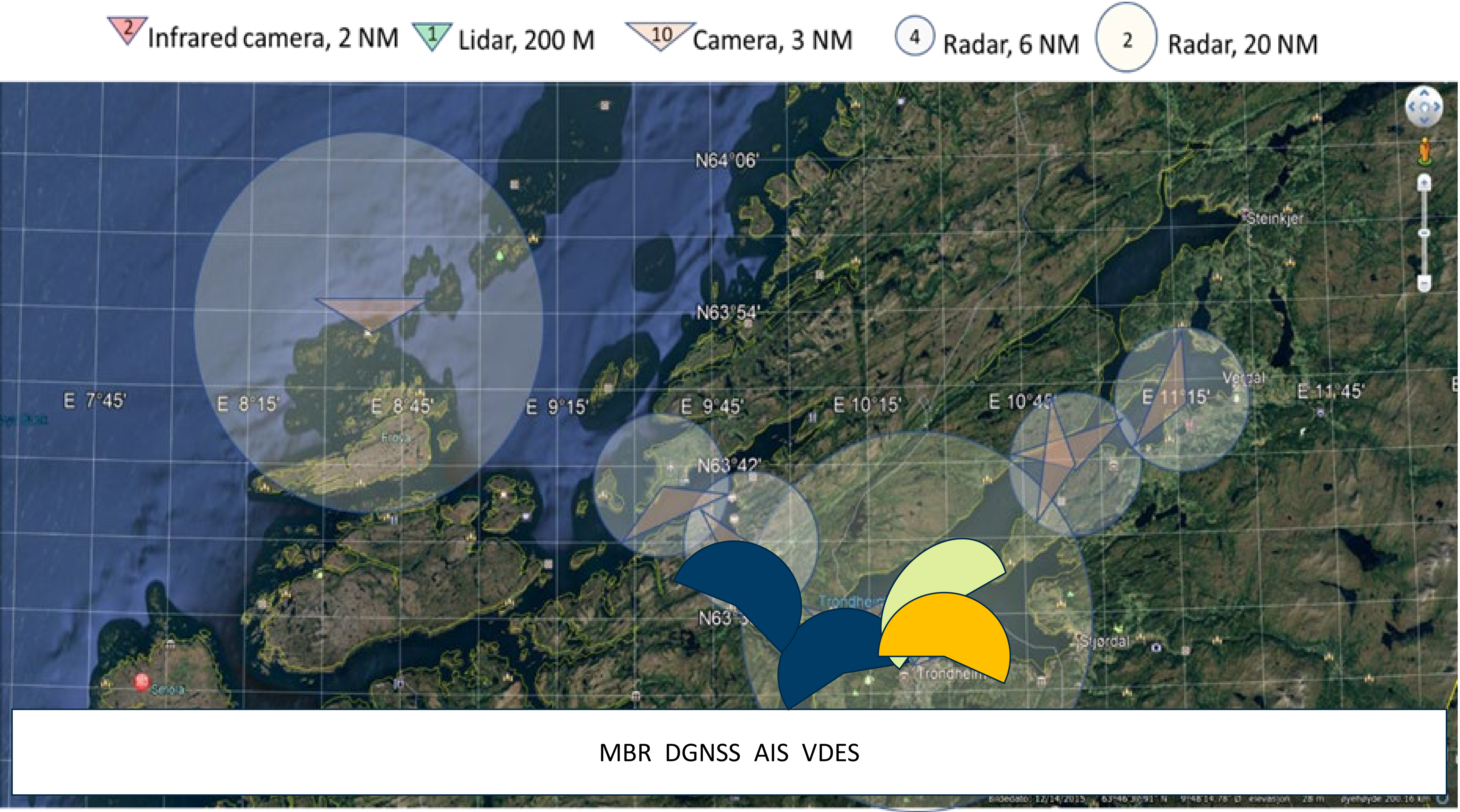
The main purpose is to define the minimum shore-based infrastructure, in order to conduct safe and cost effective integrated maritime transport operations.

Project focus areas:

- ❑ Verification and integration of land-based sensor data with sensor data from autonomous vessels.
- ❑ Adaptation of land-based surveillance technology for data fusion and automatic transfer of navigation data between infrastructure installations, control centres and vessels.
- ❑ Ensure the human-in-the loop when implementing new technology.
- ❑ Standardization of messages and technology, interaction procedures, robust technology for digital information exchange between the systems and parties.
- ❑ Development of new guidelines for interaction, new regulations and standards for information exchange.

massterly a Kongsberg Wilhelmsen joint venture KONGSBERG SINTEF NTNU

Project manager: kay.fjortoft@sintef.no



Infrared camera, 2 NM
Lidar, 200 M
Camera, 3 NM
Radar, 6 NM
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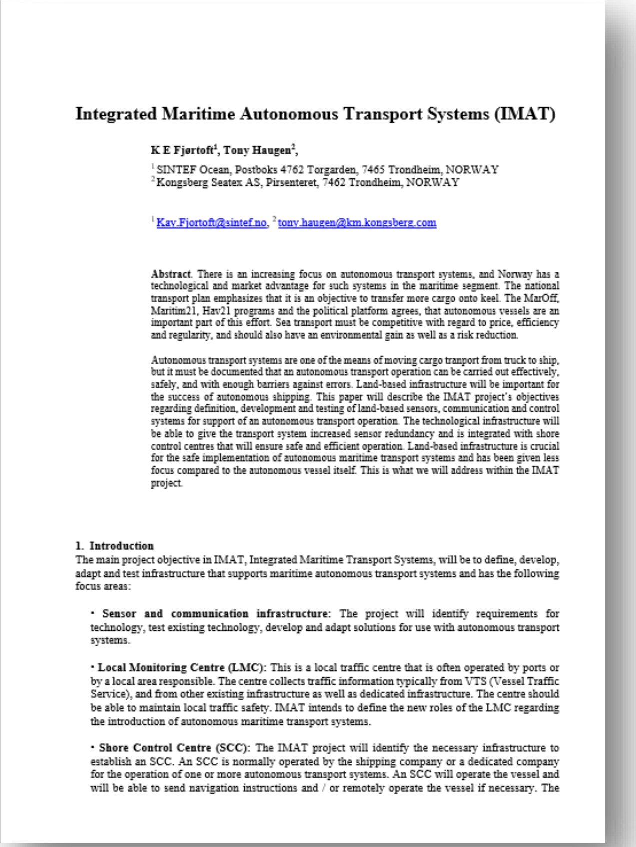
Integrated Maritime Autonomous Transport Systems

The paper; Integrated Maritime Autonomous Transport System (IMAT)



Integrated Maritime Autonomous Transport Systems (IMAT)

K E Fjørtoft[1], Tony Haugen[2],

[1] SINTEF Ocean, Postboks 4762 Torgarden, 7465 Trondheim, NORWAY
[2] Kongsberg Seatex AS, Pirsenteret, 7462 Trondheim, NORWAY

[1] Kay.Fjortoft@sintef.no, [2] tony.haugen@km.kongsberg.com

Abstract. There is an increasing focus on autonomous transport systems, and Norway has a technological and market advantage for such systems in the maritime segment. The national transport plan emphasizes that it is an objective to transfer more cargo onto keel. The MarOff, Maritim21, Hav21 programs and the political platform agrees, that autonomous vessels are an important part of this effort. Sea transport must be competitive with regard to price, efficiency and regularity, and should also have an environmental gain as well as a risk reduction.

Autonomous transport systems are one of the means of moving cargo tranport from truck to ship, but it must be documented that an autonomous transport operation can be carried out effectively, safely, and with enough barriers against errors. Land-based infrastructure will be important for the success of autonomous shipping. This paper will describe the IMAT project's objectives regarding definition, development and testing of land-based sensors, communication and control systems for support of an autonomous transport operation. The technological infrastructure will be able to give the transport system increased sensor redundancy and is integrated with shore control centres that will ensure safe and efficient operation. Land-based infrastructure is crucial for the safe implementation of autonomous maritime transport systems and has been given less focus compared to the autonomous vessel itself. This is what we will address within the IMAT project.

1. Introduction

The main project objective in IMAT, Integrated Maritime Transport Systems, will be to define, develop, adapt and test infrastructure that supports maritime autonomous transport systems and has the following focus areas:

- **Sensor and communication infrastructure**: The project will identify requirements for technology, test existing technology, develop and adapt solutions for use with autonomous transport systems.
- **Local Monitoring Centre (LMC)**: This is a local traffic centre that is often operated by ports or by a local area responsible. The centre collects traffic information typically from VTS (Vessel Traffic Service), and from other existing infrastructure as well as dedicated infrastructure. The centre should be able to maintain local traffic safety. IMAT intends to define the new roles of the LMC regarding the introduction of autonomous maritime transport systems.
- **Shore Control Centre (SCC)**: The IMAT project will identify the necessary infrastructure to establish an SCC. An SCC is normally operated by the shipping company or a dedicated company for the operation of one or more autonomous transport systems. An SCC will operate the vessel and will be able to send navigation instructions and / or remotely operate the vessel if necessary. The

- Introduction to the IMAT concept
- Integrated Maritime Autonomous System
- Addressing the hazards and compare with sensor site infrastructure
- The use case Yara Birkeland
- Summary

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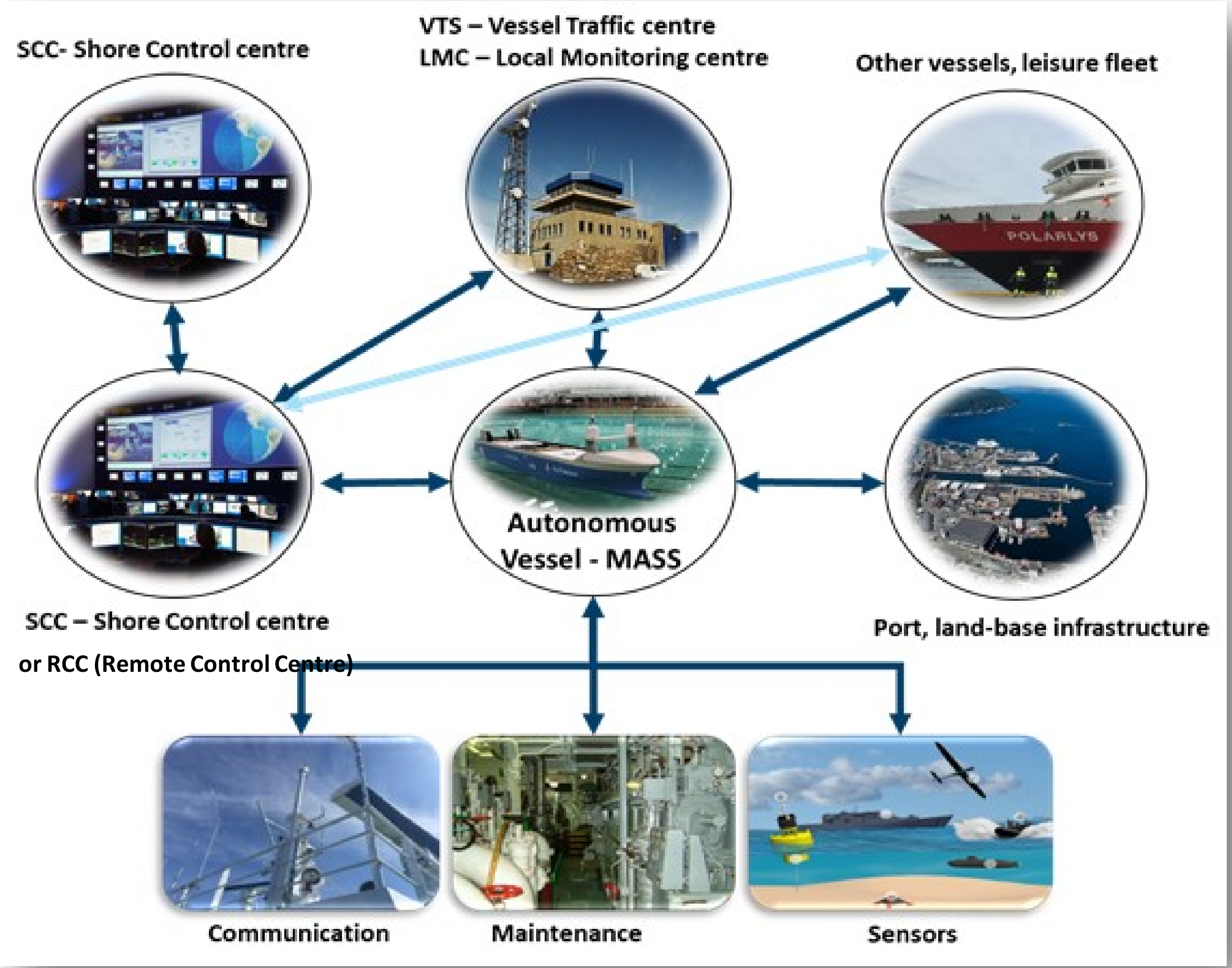
Integrated Maritime
Autonomous Transport Systems



- ⇒ *It is about the transport system, not only the vessel*
- ⇒ *Autonomous shipping needs digital infrastructure*
- ⇒ *Autonomous shipping must be safer than conventional*
- ⇒ *The humans must be is in the loop*
- ⇒ *An autonomous vessel has nothing to do in a "stupid" infrastructure that can not support operations*

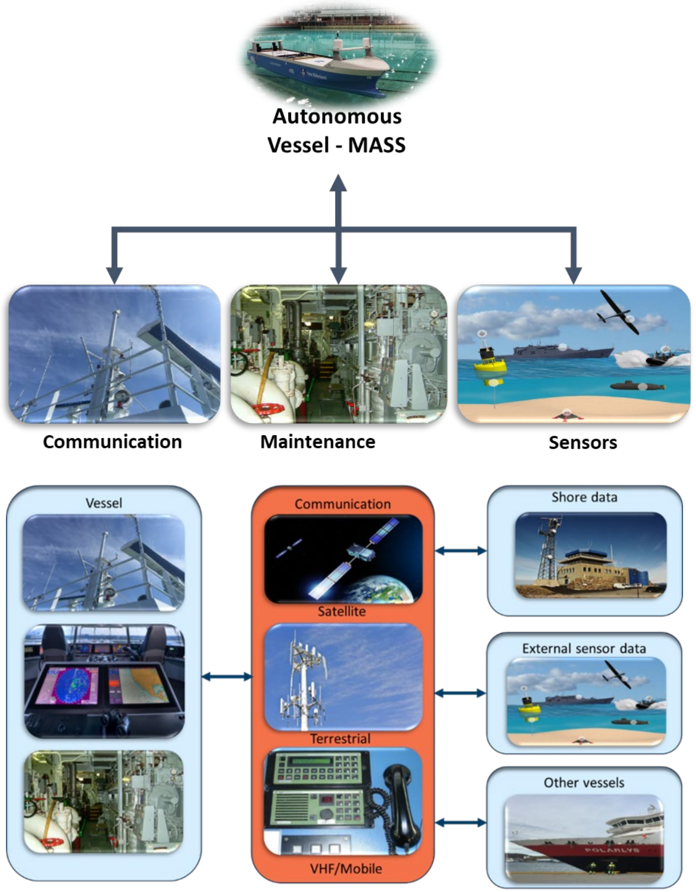
Introduction to the IMAT concept

Integrated Maritime
Autonomous Transport Systems

1. Sensors and communication infrastructure
2. Local monitoring and information Centre
3. Shore Control Centre
4. Collaboration

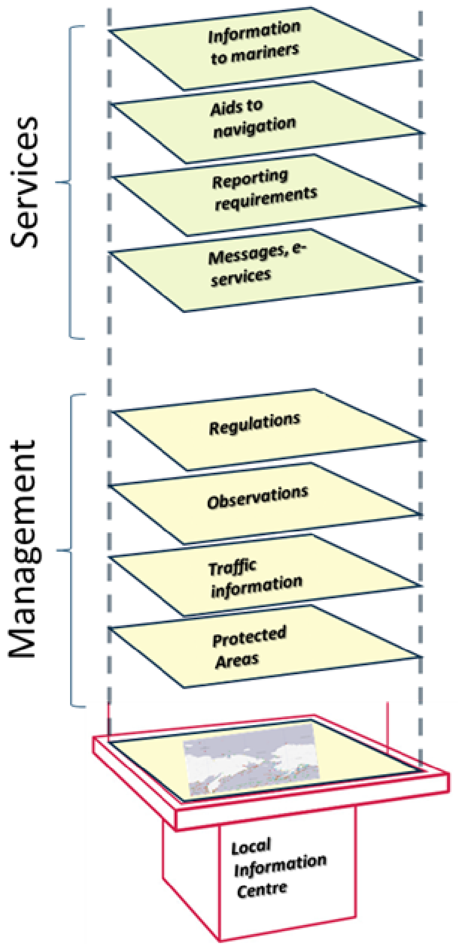
"A fully autonomous vessel will be without crew on board. How can we operate a MASS as good as, or even better than a conventional vessel with crew and how can land based infrastructure assist?".

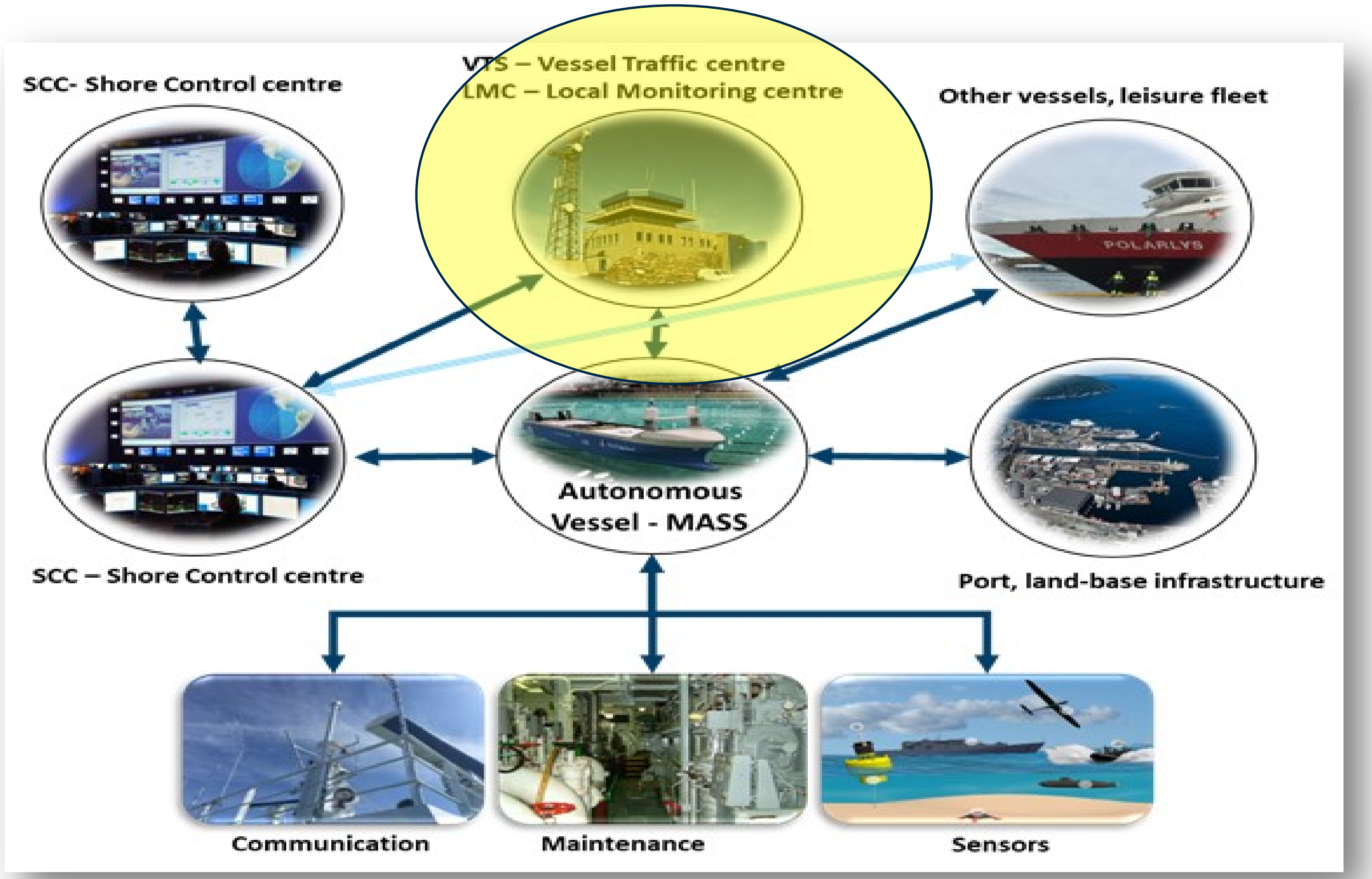
Sensor and communication infrastructure



- Sensors
  - On board the vessel
  - Sensor infrastructure
- Communication
  - On board the vessel
  - With other vessels
  - With the infrastructure
  - With the Control Centre

Local monitoring and information centre





Shore Control Centre

A Concept of Operation (CONOPS) refer to the awareness of a situation. It gives the perception of an event with respect to time and condition, and the system behavior (actual and future). A CONOPS will address the human factors in the MASS operation aspect:

- Situation and automation awareness
- The understanding between automation and human role
- User experiences and usability of the solutions
- Trust in automation
- Graphical user interface and visualization
- Hazards reflections

There are several initiatives to standardize operational procedures, and to develop guidelines how to do operation of autonomous vessels

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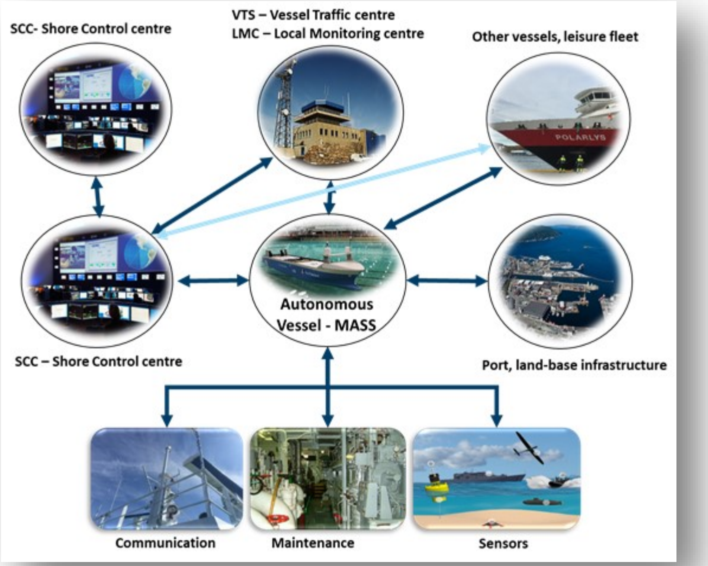
Autonomous Transport Systems

Collaboration



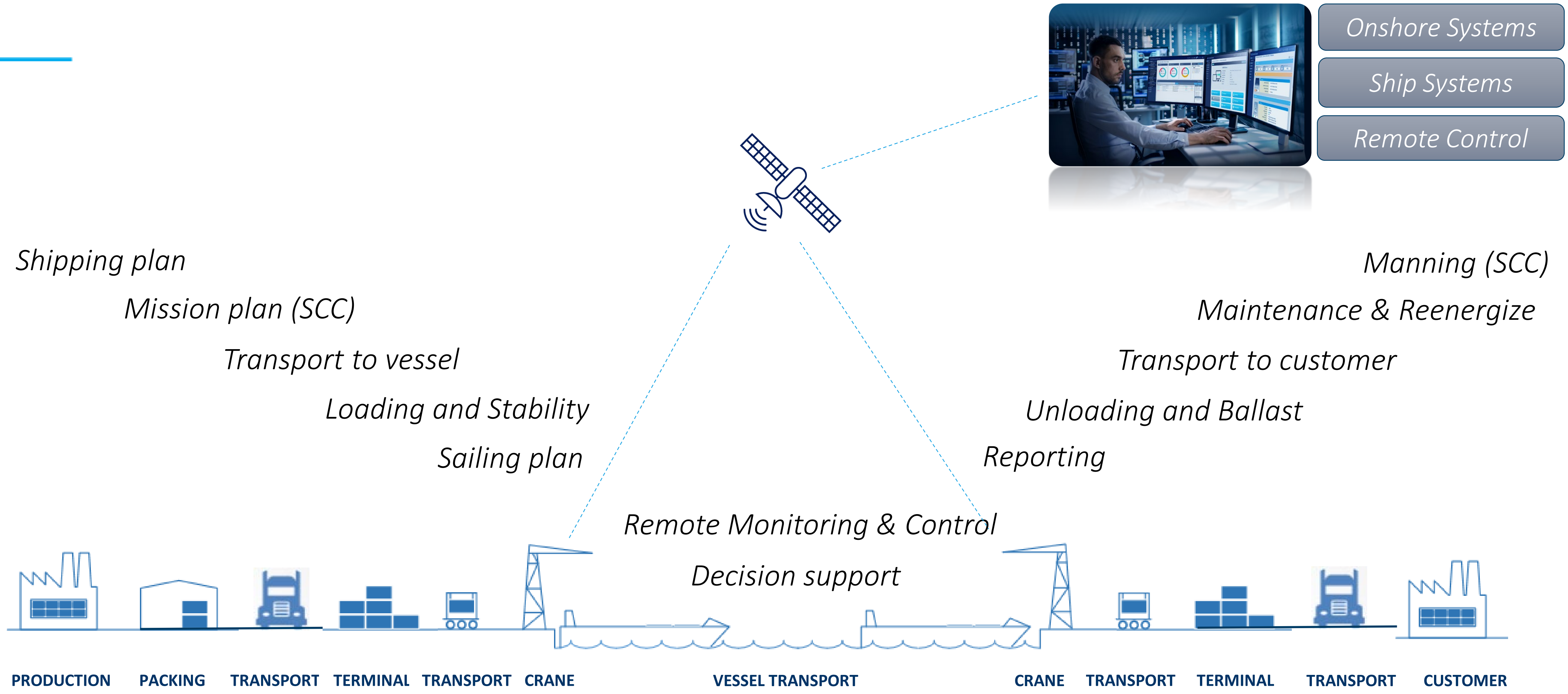
- Between technologies and sensors
- Between humans
- Between humans and machine
- Between organizations
- Between conventional and autonomous
- Between regulators and operators
- Between providers and users

The future will be more digital, and Machine to Machine integration will be normal procedure.

The humans will still be in the loop, but in "another loop".

Integrated Maritime Autonomous System

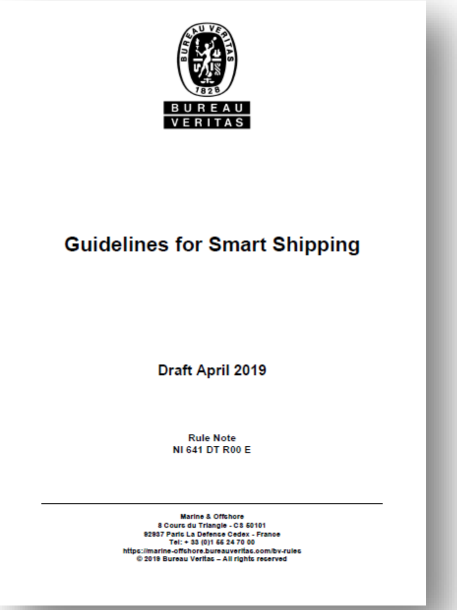
Integrated Maritime Autonomous Transport Systems



Source: Massterly

Addressing the hazards and compare with sensor site infrastructure

	Publisher	Name	Date
1	DNV GL	Class Guideline: Autonomous and remotely operated ships	Sept. 2018
2	Lloyd's Register	Cyber-enabled ships (2 doc): - Deploying information and communications technology in shipping –LR's approach to assurance - ShipRight procedure assignment for cyber descriptive notes for autonomous & remote access ships (guidance document)	Feb 2016 Dec 2017
3	Bureau Veritas (BV)	Guidelines for Smart Shipping (DRAFT)	April 2019
4	ClassNK Japan	Guidelines for Concept Design of Automated Operation/Autonomous Operation of ships (Provisional Version)	June 2018
5	Maritime UK	Maritime Autonomous Surface Ships - UK Code of Practice (A voulnatry code)	Nov. 2018
6	Sjøfartsdir.	Krav til dokumentasjon I forbindelse med bygging av autonome, ubemannede og/ eller fjernstryrte fartøy (utkast)	April 2019
7	Danish Maritime Authority (DMA)	Analysis of regulatory barriers to the use of autonomous ships (final report)	Dec. 2017


BUREAU VERITAS

Guidelines for Smart Shipping

Draft April 2019

Rule Note
NI 641 DT R00 E

Marine & Offshore
8 Cours du Triangle - CS 50101
92937 Paris La Defence Cedex - France
Tel: + 33 (0)1 55 24 70 00
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- Hazards for the voyage
- Hazards for the navigation
- Hazards for the detection
- Hazards for the communication
- Hazards for the ship integrity, machinery and systems
- Hazards for the cargo and passenger management
- Hazards for the remote control
- Hazards for the security

Hazards for the voyage

		Sensor Site
Hazards for the voyage	Human error in input of voyage plan	
	Failure of updated information (nautical, weather, publications)	
	Failure in position fixing (due to e.g. GPS selective availability)	

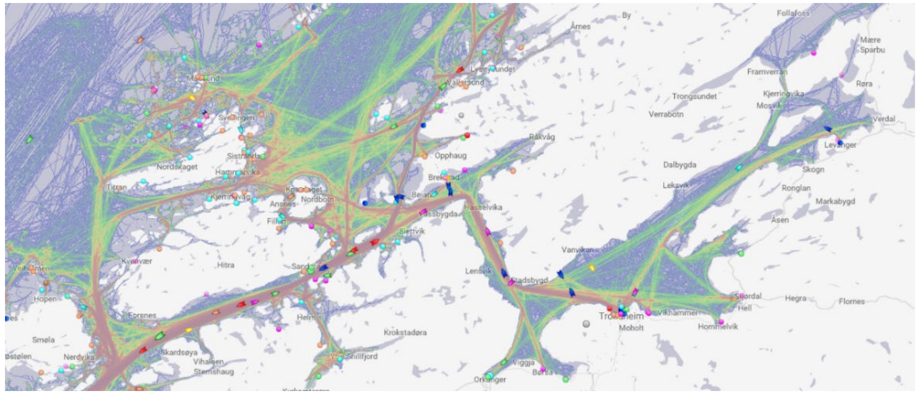


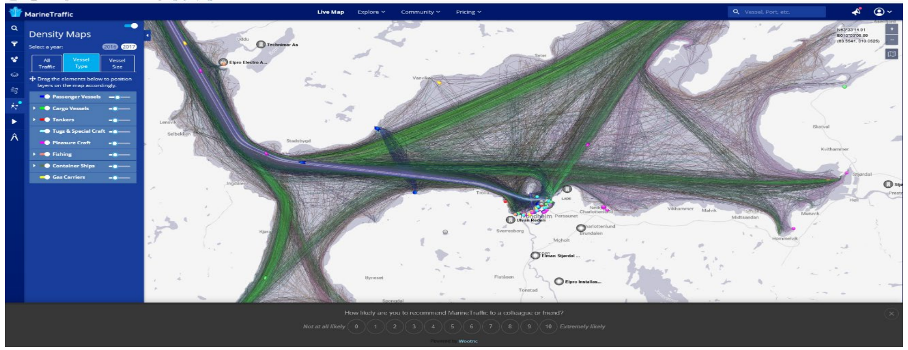
Figure 1 - Density map. Source: Marinetraffic.com

- Hazards for the voyage
  - Planning of an operation
  - The interaction between SCC and the MASS
  - The infrastructure, sensors and communication capabilities
  - The possibilities to recover

It must be possible to use different sensor sources, for positioning fixing. Cyber attack such as jamming is more and more common. Resilient PNT (Position, Navigation, Timing) is important for autonomous shipping.

Hazards for the navigation

Hazards for the navigation	Heavy traffic	
	Heavy weather or unforeseeable events (e.g. freak wave)	
	Low visibility	
	Collision with other ships or offshore infrastructures	
	Collision with floating objects	
	Collision with marine wildlife (e.g. whales, squids, carcasses)	
	Collision with onshore infrastructures or failure in mooring process	
	Loss of intact stability due to unfavorable ship responses (e.g. to waves)	
	Loss of intact stability due to icing	



- Shore-based infrastructure can be used for
  - Identify traffic (AIS, Camera, Radar, histogram, etc)
  - Identify weather (weather radars, met.no, information sources)
  - Identify visibility (land based infrastructure as an extra eye)
  - Collision avoidance (traffic tools, ECDIS, etc)
  - *Collision with objects (position based on observations, inform vessels)*
  - *Collision wildlife (avoid area, notify traffic from land based sources)*
  - Collision infrastructure (redundancy, human interventions when needed, assistance in navigation)
  - *Loss of stability due to ship response (hard to trust land-based infrastructure)*
  - *Loss of stability due to ship response (hard to detect ice from shore infrastructure)*

Hazards for the detection	Failure in detection of small objects (wreckage)	
	Failure in detection of collision targets	
	Failure in detection of navigational marks	
	Failure in detection of ship lights, sounds or shapes	
	Failure in detection of semi-submerged towed or floating devices (e.g. seismic gauges, fishing	
	Failure in detection of discrepancy between charted and sounded water depth (e.g. wreckage)	
	Failure in detection of discrepancy between weather forecast and actual weather situation	
	Failure in detection of slamming or high vibration	

Figure 1 - Hazards for the detection

Hazards for the communication	Reduction of communication performance (e.g insufficient bandwidth)	
	Communication failure (e.g. with SCC, with relevant authorities, with ships in vicinity)	
	Communication failure with another ship in distress	
	Failure in data integrity (e.g. error in data transmission)	

Figure 1 - Hazards for the communication

Hazards for the ship integrity, machinery and systems	Water flooding due to structural damage or watertightness device failure	
	Fire	
	Sensor or actuator failure	
	Temporary or permanent loss of electricity (e.g. due to black-out)	
	Propulsion or steering failure	
	Failure of ship's IT systems (e.g. due to bugs)	
	Failure of ship's IT infrastructure (e.g. due to fire in the server room)	
	Failure of anchoring devices when drifting	

Figure 1 - Hazards for the cargo and passenger management

Hazards for the cargo and passenger management	Too many cargo or passenger aboard (overload)	
	Loss of intact stability due to shift and/or liquefaction of cargo or due to cargo overboard	
	Passenger overboard	
	Passenger illness	
	Passenger injured during arrival or departure	
	Passenger interfering in an aboard system	

Figure 1 - Hazards for the cargo and passenger management

Hazards for the remote control	Unavailability of SCC (fire, environmental phenomenon...) or of operators (faitness, emergency situation, etc.)	
	Human error in remote monitoring and control (e.g. through situation unawareness,	
	Human error in remote maintenance	

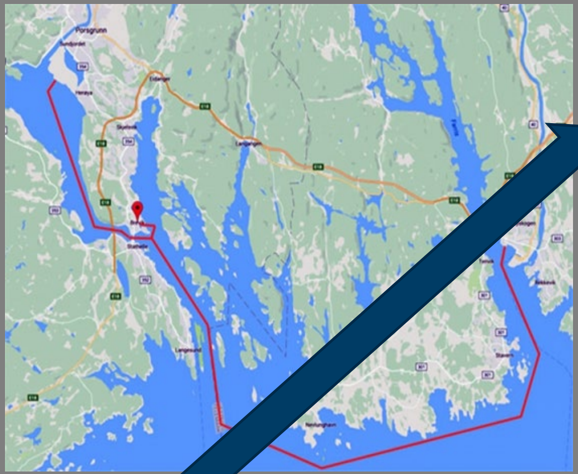
Figure 1 - Hazards for the remote control

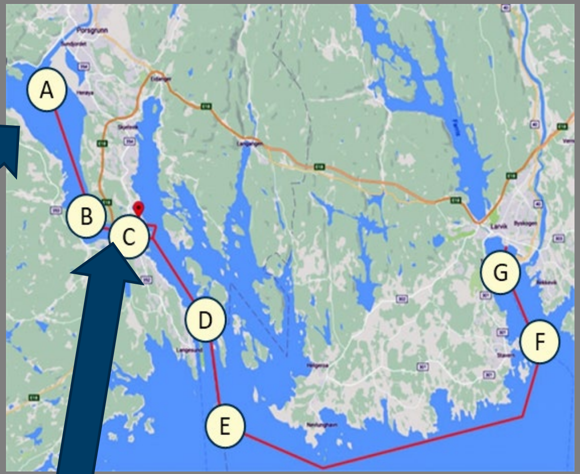
Hazards for the security	Willful damage to ship structures by others (e.g. pirates, terrorists)	
	Attempt of unauthorised ship boarding (e.g. pirates, terrorists, stowaways, smugglers)	
	Jamming or spoofing of AIS or GPS signals	
	Jamming or spoofing of communications, hacker attack, also on RCC (e.g. in case of pirate or terrorist attack)	
	Failure in data confidentiality (e.g. data interception by unauthorized 3rd party)	

Figure 1 - Hazards for the security

Yara Birkeland

- A possible way of planning a voyage





Position	Planned		Info object	Status/Deviation
	Operations/Time	Sensors available		
A (59.12, 9.61)	• Dep: 10:00 • Send dep message and voyage plan to LMC and VTS • Speed: 4 knots • SCC info on AIS-message	• Port camera (Cam Cam_2) • Vessel camera (Cam_1, Cam_ • AIS-picture • Radar • MetHyd-data • 4G coverage		Dep: 10:02

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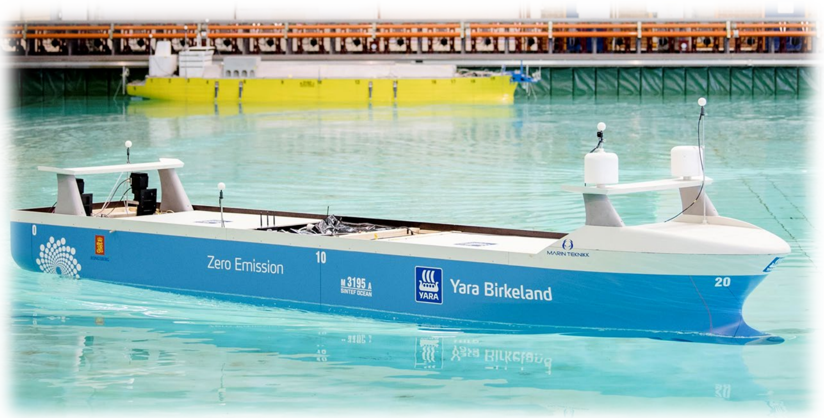
The use case Yara Birkeland



- The autonomous transport operation planned for Yara Birkeland is the first real autonomous transport operation planned of this scale. CONOPS is one way of planning.
  - Experiences from conventional shipping. Three steps
    1. with crew
    2. remote operation,
    3. computer based sailing
- Testa areas for autonomous ships is important in the development steps of safe autonomous maritime ship.

Summary

- The main objectives of the IMAT project is to define, develop and test the minimum land-based infrastructure
- It is essential to build confidence regarding safety
- Safe development must be done by focusing the:
  - Technology, standards, sensors and infrastructure
  - The information needs for decision making, and the human knowledge and the humans place in the loop
  - Regulations and operational requirements
- **Shore-based infrastructure will be important for the planning of a robust autonomous transport system**

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