massterly
a Kongsberg Wilhelmsen joint venture

Managing and Monitoring of vessels with reduced or no crew

Baltimore – 22nd July 2019
by Tom Eystø (CEO of Massterly)

Massterly is Kongsberg and Wilhelmsen's joint effort to develop the autonomous maritime market

TECHNOLOGY

- Leading in development of autonomy
- Frontrunner in digital development
- In front on cyber security

OPERATION

- Leading vessel operator
- Major logistics operator at sea and on land
- One of the largest maritime network globally

The different autonomy levels as per NMA

Sjøfartsdirektoratet
Norwegian Maritime Authority

1. **Decision support:** Advanced anti-collision radars, ECDIS, autopilot & track pilots. Crew in direct command of ship operations.

2. **Automatic:** Can complete demanding operations without human interaction, e.g. dynamic positioning or automatic berthing. The bridge crew is always available to intervene.

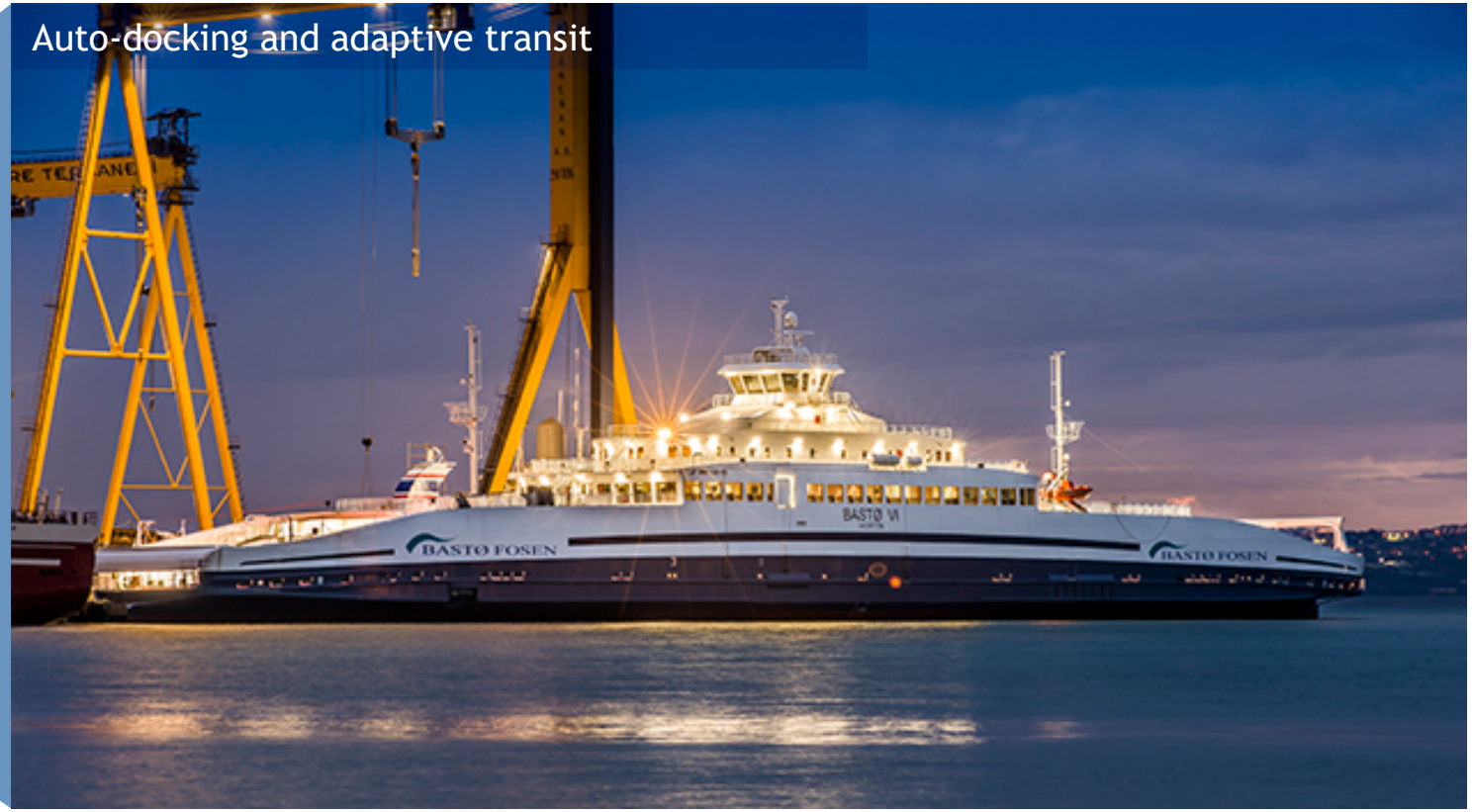
3. **Periodically unmanned**: E.g. at night in good weather and without much traffic. Crew onboard or in escort vessel will be alarmed if there are situations the system is unable to handle.

4. **Unmanned:** No crew onboard, but direct or indirect control from shore to handle complex operations. SCC continuously supervises operations and will take immediate control when needed.

5. **Fully autonomous:** The ship handles all situations by itself, no SCC or bridge personnel at all. Unlikely scenario in the medium term due to very high complexity and the need for vessel to be under someone's command and communicate with others.

Automatic bridge – Operator assistance

Operational autonomy levels	Manning levels		
	Manned bridge	Unmanned bridge – crew on board	Unmanned bridge – no crew on board
Decision support	Direct control No autonomy	Remote control	Remote control
Automatic	Automatic bridge	Automatic ship	Automatic ship
Constrained autonomous	-	Constrained autonomous	Constrained autonomous
Fully autonomous	-	-	Fully autonomous



Remote control

Operational autonomy levels	Manning levels		
	Manned bridge	Unmanned bridge – crew on board	Unmanned bridge – no crew on board
Decision support	Direct control No autonomy	Remote control	Remote control
Automatic	Automatic bridge	Automatic ship	Automatic ship
Constrained autonomous	-	Constrained autonomous	Constrained autonomous
Fully autonomous	-	-	Fully autonomous

Constrained autonomous

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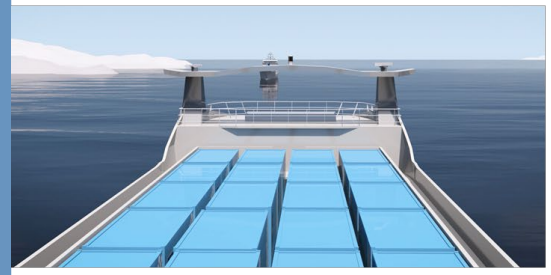
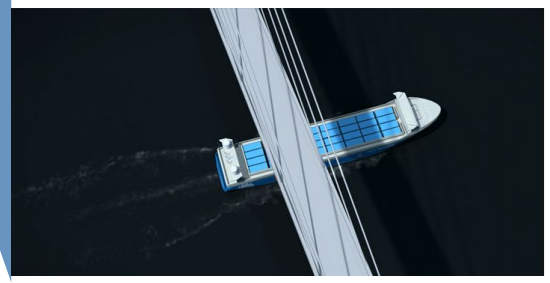
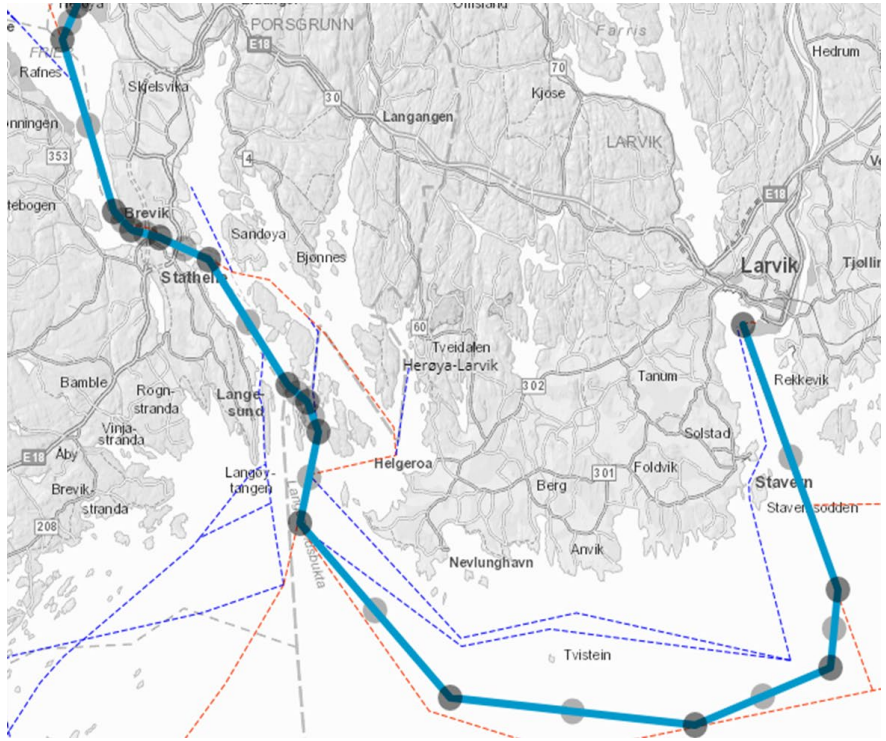
Autonomous trailer transport

Yara Birkeland Operational area

Yara Birkeland







Fully autonomous

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Fully autonomous	-	-	Fully autonomous

Sea-bed exploration (USV with AUV)

The regulatory landscape; a showstopper?

"Maritime Autonomous Surface Ship (MASS)" is defined as a ship which, to a varying degree, can operate independently of human interaction.

- No IMO regulations for autonomous operations have been developed
- IMO has started a scoping exercise. Timeline to regulations; 10 years ++
- National or regional regulatory bodies are free to support the introduction of novel technologies and operational concepts within their territorial waters.

Technology Qualification as per MSC.1/Circular 1455:
Demonstrate level of safety equivalent or better compared to conventional vessels

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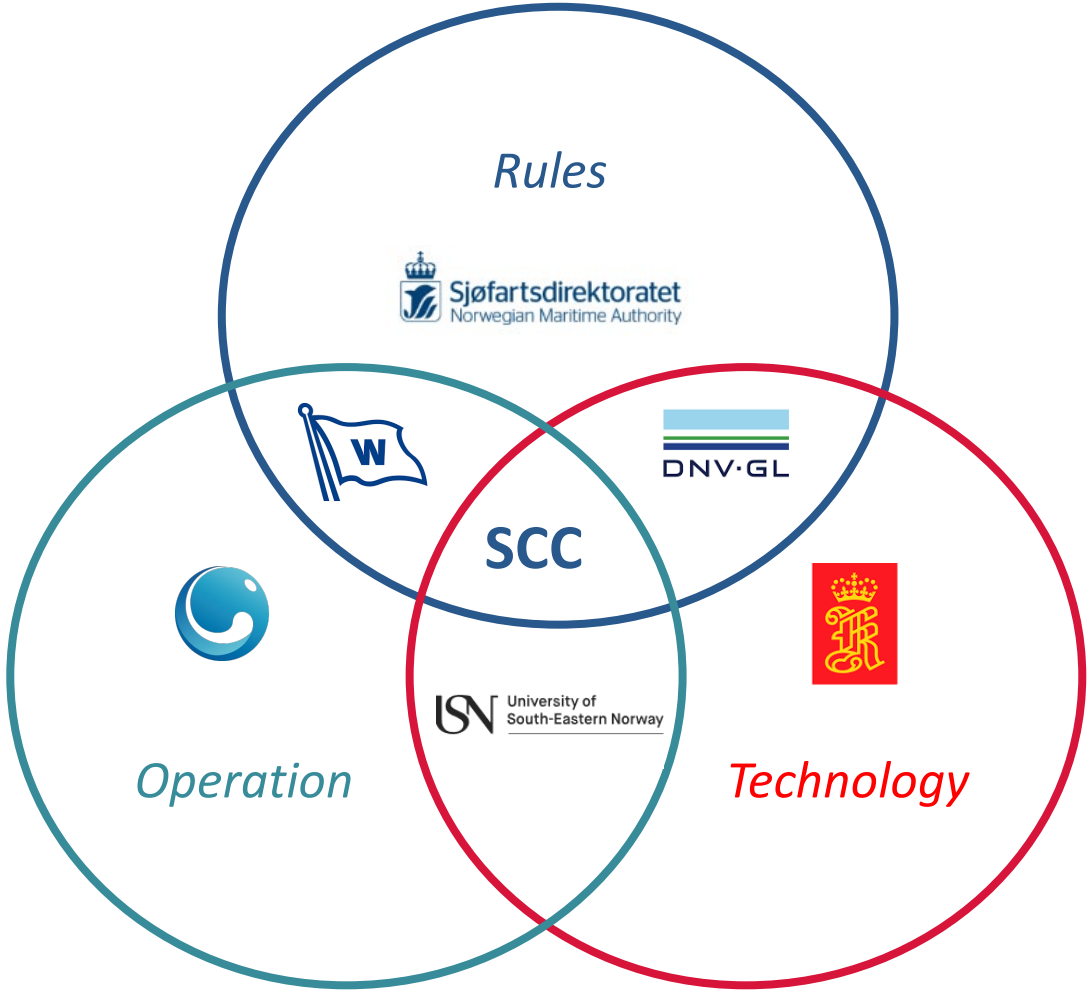
The ISM code was made mandatory by IMO in 1998

Both the Company and the ship must comply

Interplay between technology and operation is crucial to succeed

Main focus in the debate is on autonomy technology, but operation is equally important

- How will these vessels be operated?
- Under what rules and guidelines?
- Is a Shore Control Centre (SCC) required?
- What is the approval process for SCC?
- Competency required for SCC operators?
- Legal aspects
- Division of responsibilities
- Insurance



Shaping the regulatory framework in autonomous shipping through interdisiplinary collaboration

Safety Management System	
Wilhelmsen Ship Management DNV·GL Sjøfartsdirektoratet Norwegian Maritime Authority	Development of an efficient SMS for operating autonomous, remotely controlled and remotely supported vessels

Competence solution	
Wilhelmsen Ship Management DNV·GL USN University of South-Eastern Norway	Development of a competence solutions required in a control center to manage and operate autonomous, remotely controlled and remotely supported vessels

Traditional roles will be disrupted

THE BRIDGE TEAM

SUPERVISOR

Master
Ultimate responsibility for the safety of the ship

OPERATOR

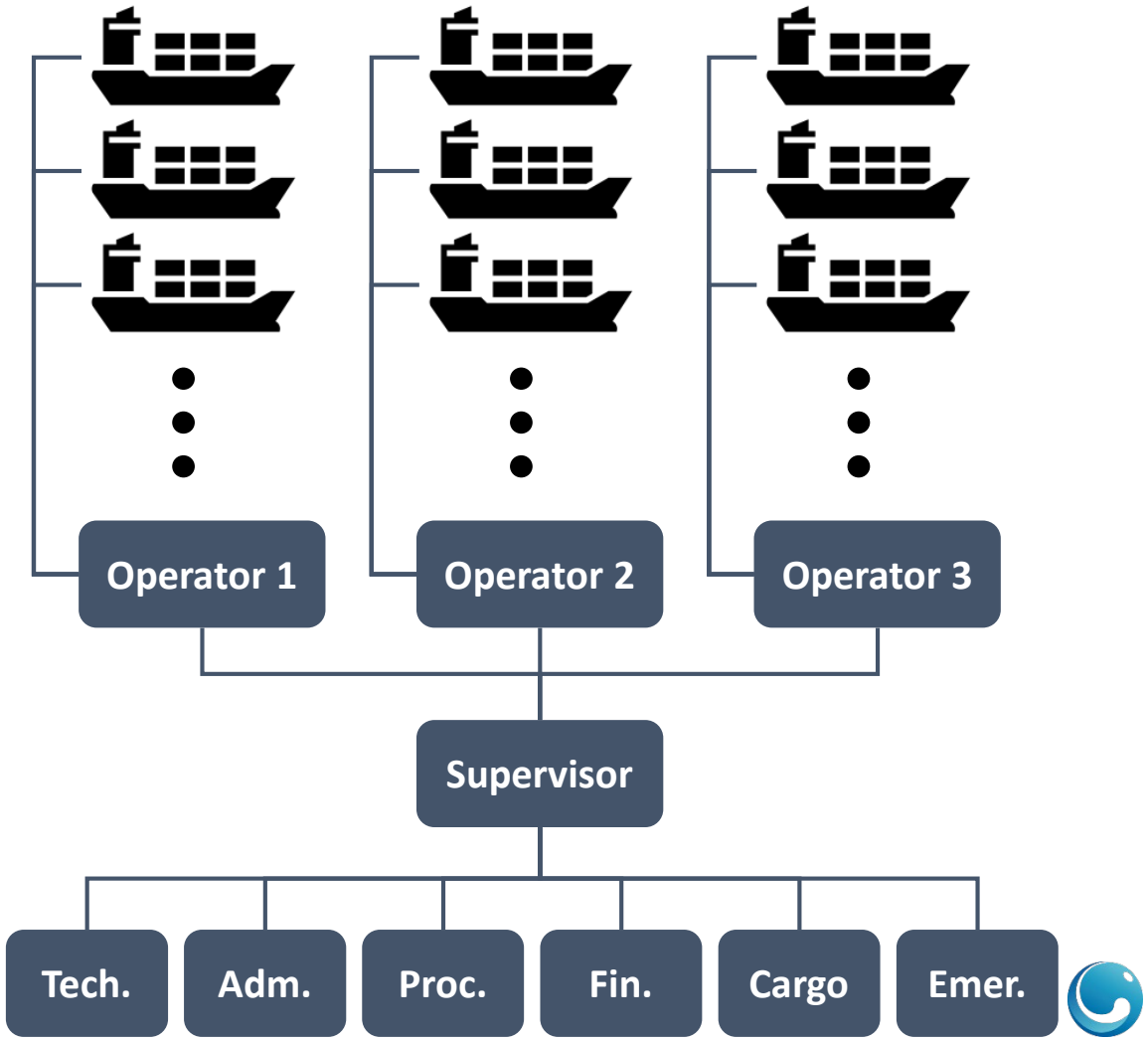
Officer On Watch
Responsible for managing the bridge team and accountable to the Master for safe navigation of the ship

AUTONOMY

Look-out
An all round look-out by sight and hearing, reporting all sightings to the Officer On Watch

Helmsman
Executes steering instruction from the Officer On Watch

THE SHORE CONTROL CENTRE



Transition from today's role-based approach to a goal-based approach is required to succeed with optimization

Role based approach

Who does what ?

Function and goal based approach

Actions driven by objectives

Mapping all activites and processes onboard a vessel during operations – with applicable regulations

CC Req.	Phas	Subprocess	C	Ful	Obligati	Trigger	Process word	Object	Legal Regulations
40201	Sailing	Identify targets	SCC	The A	must	be capable to	receive	information on aids to navigation from sea charts (e.g. lighthouses, buoys, coastlines)	STCW A-VIII/2 Part 4-1 (14-17)
40202	Sailing	Identify targets	SCC	The A	shall		identify	objects in vicinity (e.g. ships, aids to navigation, floating debris, PIWs)	STCW A-VIII/2 Part 4-1 (14-17)
40203	Sailing	Identify targets	SCC	The A	must		evaluate	the identified position of aids to navigation in comparison with the supposed position according to sea charts	STCW B-II/1 (11.1.1)
40204	Sailing	Identify targets	SCC	The A	must		identify	deviations between actual position of aids to navigation with supposed position	SOLAS Chapter V R19 2.1.3
40205	Sailing	Identify targets	SCC	The A	must		notify	the SCC (if discrepancies with the position of an aid to navigation is detected)	---
40206	Sailing	Identify targets	SCC	The A	must	be capable to	receive	data from own ship sensors (position data)	SOLAS Chapter V R19 (2.1.6)
40207	Sailing	Identify targets	SCC	The A	must	be capable to	receive	navigational warnings by NAVTEX	SOLAS Chapter IV Part B R7 1.4
40208	Sailing	Identify targets	SCC	The A	must	be capable to	receive	information about ships and objects in own ships vicinity by AIS	SOLAS Chapter V R19 2.4
40209	Sailing	Identify targets	SCC	The A	must	be capable to	receive	information on other ship's maneuverability	SOLAS Chapter V R19 2.4 COLREG Part C
40210	Sailing	Identify targets	SCC	The A	must	be capable to	receive	data from own ship sensors (acoustic information)	SOLAS Chapter V R19 (2.1.8)
40211	Sailing	Identify targets	SCC	The A	must		provide	enriched ECDIS information, containing traffic situation, objects etc. to other ABS processes	SOLAS Chapter V R19 (2.1.4)
40212	Sailing	Identify targets	SCC	The A	must	offer SCC the possibility to	access	enriched ECDIS information, containing traffic situation, objects etc.	SOLAS Chapter V R19 (2.1.4)
40213	Sailing	Identify targets	SCC	The A	must	offer SCC the possibility to	access	all surveillance data / information in a suitable manner	MSC.252(83)
40214	Sailing	Identify targets	SCC	The A	must	offer OBP the possibility to	access	information about the current traffic situation	COLREG R5 SOLAS Chapter V R19
40215	Sailing	Identify targets	SCC	The A	must		provide	a time frame for the data that is forwarded to the SCC or to other ABS processes	---
40301	Sailing	Provide radar/ARPA picture	SCC	The A	must	be capable to	receive	data from own ship sensors (radar/ARPA)	SOLAS Chapter V R19 2.3.2/2.3.3/2.7
40302	Sailing	Provide radar/ARPA picture	SCC	The A	must	be capable to	receive	information about ships and objects in own ships vicinity by radar/ARPA	SOLAS Chapter V R19 2.3.2/2.3.3/2.7
40303	Sailing	Provide radar/ARPA picture	SCC	The A	shall	offer SCC the possibility to	define	the radar/ARPA input parameters (if it is not automatically set)	SOLAS Chapter V R19 2.3.2/2.3.3/2.7
40304	Sailing	Provide radar/ARPA picture	SCC	The A	must		detect	objects in vicinity (e.g. ships, aids to navigation, floating debris, PIWs) by radar/ARPA	STCW A-VIII/2 Part 4-1 (14-17)
40401	Sailing	Provide CCTV picture	SCC	The A	must	be capable to	to receive	data from own ship sensors (CCTV information: object detection)	COLREG R5
40402	Sailing	Provide CCTV picture	SCC	The A	must		detect	objects in vicinity (e.g. ships, aids to navigation, floating debris, PIWs) by	CCTV COLREG R5/R19
40403	Sailing	Provide CCTV picture	SCC	The A	must	be capable to	evaluate	information about ships and objects in own ships vicinity by visual means (CCTV)	COLREG
40404	Sailing	Provide CCTV picture	SCC	The A	must	be capable to	consider	CCTV information (to capture current environmental condition, e.g. visibility, cloud picture and movement, sea state)	0
40501	Sailing	Relay voice radio	SCC	The A	must/shall	be capable to	receive	Radio messages	SOLAS Chapter IV Part C R6.3/R12
40502	Sailing	Relay voice radio	SCC	The A	must/shall	be capable to	evaluate	Radio messages	SOLAS Chapter IV Part C R6.3/R12
40503	Sailing	Relay voice radio	SCC	The A	must/shall	be capable to	transmit	Radio messages	SOLAS Chapter IV Part C R6.3/R12 STCW B-II/1 (11.9)
40601	Sailing	Measure weather data	SCC	The A	must	be capable	to receive	data from own ship meteorological sensors	STCW Table A-II/1 and Table A-II/2
40602	Sailing	Measure weather data	SCC	The A	must	be capable	to consider	Radar/ARPA information (to identify current sea state)	COLREG R6 a) SOLAS Chapter V R19 2.3.2/2.3.3/2.7
40603	Sailing	Measure weather data	SCC	The A	must	0	identify	current sea state information	STCW A-VIII/2 Part 4-1 (16.2 & 17.1)
40604	Sailing	Measure weather data	SCC	The A	must	0	detect	areas of limited visibility	COLREG R19
40701	Sailing	Ship dynamics	SCC	The A	must	be capable to	receive	current sea charts (to be able to identify impact of shallow or narrow waters on maneuvering properties)	STCW A-VIII/2 Part 2 (5)
40702	Sailing	Ship dynamics	SCC	The A	must	be capable to	receive	current water depth from echo sounder (to be able to identify impact of shallow or narrow waters on maneuvering pro	SOLAS Chapter V R19 2.3.1
40703	Sailing	Ship dynamics	SCC	The A	must	be capable to	receive	information on environmental conditions	STCW A-VIII/2 Part 4-1 (16.2)
40704	Sailing	Ship dynamics	SCC	The A	must	be capable to	receive	further navigational data (course over ground, heading, position, speed, under-keel clearance)	IMO Resolution A.601(15) MSC.137(76)
40705	Sailing	Ship dynamics	SCC	The A	must	be capable to	receive	current stability conditions	IS Code Res.A.749 (18) MSC/Circ.920
40706	Sailing	Ship dynamics	SCC	The A	must		initiate	a calibration by performing likely maneuvers	IMO Resolution A.601(15) MSC.137(76)
40707	Sailing	Ship dynamics	SCC	The A	shall		learn	from maneuvers previously carried out to improve its calibration	IMO Resolution A.601(15) MSC.137(76)
40708	Sailing	Ship dynamics	SCC	The A	must		consider	the effects of wind, sea state and current on own ships maneuvering properties	IMO Resolution A.601(15) MSC.137(76)
40709	Sailing	Ship dynamics	SCC	The A	must		consider	the effects of shallow or narrow waters	STCW Table A-II/2
40710	Sailing	Ship dynamics	SCC	The A	must		consider	possible restrictions on own ships maneuvering abilities (if e.g. engine availability is restricted)	COLREG R6 a)iii
40711	Sailing	Ship dynamics	SCC	The A	must		consider	specific constant ship characteristics (e.g. dimensions)	IMO Resolution A.601(15) MSC.137(76)
40712	Sailing	Ship dynamics	SCC	The A	must		determine	constantly the ships maneuvering characteristics	IMO Resolution A.601(15) MSC.137(76)
40713	Sailing	Ship dynamics	SCC	The A	must		determine	own ships maneuvering characteristics under different conditions (e.g. speed, sea state, water depth)	IMO Resolution A.601(15) MSC.137(76)
40714	Sailing	Ship dynamics	SCC	The A	must		provide	own ships maneuvering characteristics to other ABS processes	IMO Resolution A.601(15) MSC.137(76)
40715	Sailing	Ship dynamics	SCC	The A	must		offer SCC the possibility to	access own ships current maneuvering characteristics	---
40716	Sailing	Ship dynamics	SCC	The A	must		provide	a time frame for the data that is forwarded to the SCC or to other ABS processes	---
40801	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (compass)	SOLAS Chapter V R19 2.1.1 MSC.252(83)
40802	Sailing	Navigation	SCC	The A	must		determine	compass error	SOLAS Chapter V R19 2.1.3 STCW B-II/1 (11.1.5)
40803	Sailing	Navigation	SCC	The A	must		perform	correction of compass error (if compass error is identified)	SOLAS Chapter V R19 2.1.3 STCW B-II/1 (11.1.5 & 1
40804	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (speed log data)	SOLAS Chapter V R19 2.3.4 MSC.252(83)
40805	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (radio navigation data)	SOLAS Chapter V R19 2.1.6 MSC.252(83)
40806	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (radar/ARPA navigation data)	COLREG R5/R6/R7/R19 SOLAS Chapter V R19 2
40807	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (GNSS)	SOLAS Chapter V R19 2.1.6 MSC.252(83)
40808	Sailing	Navigation	SCC	The A	must	be capable to	receive	data from own ship sensors (automatic sextant: position of celestial bodies)	STCW B-II/1 (11.1.7)
40809	Sailing	Navigation	SCC	The A	must		evaluate	data from own ship sensors (to determine position and heading)	STCW B-II/1 (11.2) MSC.252(83)
40810	Sailing	Navigation	SCC	The A	must		calculate	own ships position and heading by more than one method (including terrestrial, celestial and technical navigation tec	STCW Table A-II/1
40811	Sailing	Navigation	SCC	The A	must		evaluate	own ships position depending on different methods of positioning	STCW Table A-II/1
40812	Sailing	Navigation	SCC	The A	must		identify	deviations of own ships position calculated by different methods	STCW Table A-II/1
40813	Sailing	Navigation	SCC	The A	must		notify	the SCC (if ambiguity of own ship's position is found)	---
40814	Sailing	Navigation	SCC	The A	must		calculate	own ships movements based on data from own ship sensors (speed, acceleration, heading, roll, pitch, yaw, surge, sw	STCW A-VIII/2 Part 4-1 (25)
40815	Sailing	Navigation	SCC	The A	must		provide	information on own ships position, heading andmovement to other ABS processes	SOLAS Chapter V R28 (2)

q. | USNFunctions | USNDefinitions | Massterly | Camera | KPIs | Alarm Emergencies | Avoid Collision!!! | Buoyancy | Follow Track | Lookout | ... ⊕

Shore Control Centre tasks

- **Mission Planning**
- **Operation Monitoring**
- **Maintenance**
- **Exception Handling**

- ✓ Vessel to handle the berth to berth voyage without assistance
- ✓ When the integrity of the vessel is challenged the SCC will be notified (alarm)
- ✓ If the SCC comms. link is interrupted autonomous system on board takes control
- ✓ The SCC may update mission & give direct commands at any time


Norway
United Kingdom
Iceland

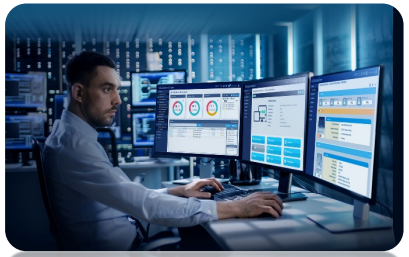
KONGSBERG

High Attention View

What shall we deliver?

Environmentally friendly logistics
enabling the shift from road to sea

Not only about replacing onboard crew
Many different activities and data sources must be integrated to create real value in the logistics chain



Onshore Systems

Ship Systems

Remote Control

Shipping plan

Mission plan (SCC)

Transport to vessel

Loading and Stability

Sailing plan

Manning (SCC)

Maintenance & Reenergize

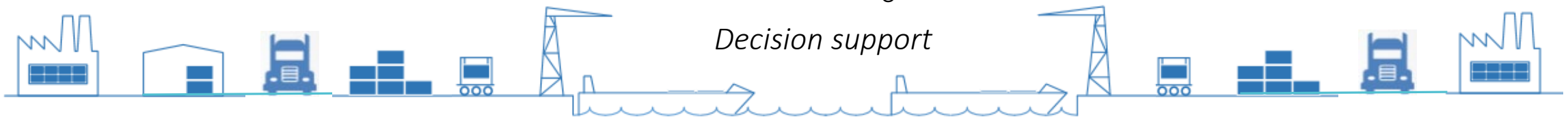
Transport to customer

Unloading and Ballast

Reporting

Remote Monitoring & Control

Decision support



COMPANY
Massterly

CORE BUSINESS
Shore Control Center (SCC)

BUSINESS AREA
Advanced logistics operations

BUSINESS AREA
OPEX reduction of vessel operation

MARKET
Short sea logistics

MARKET
Global shipping fleet

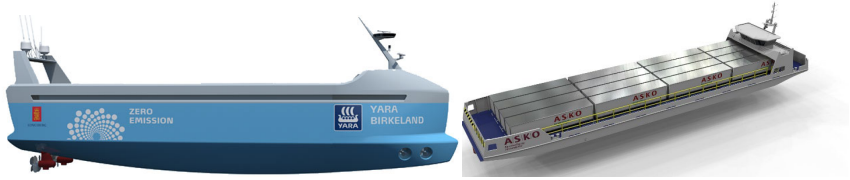
We work with customers requesting varying degree of autonomy

Degree of unmanned

Unmanned vessel

Reduced crew

Full crew



Cost-effective logistics,
moving goods by sea rather than truck

"Next Generation Shipping"
OPEX reduction
(fuel, crew, maintenance)

Conventional vessel

Autonomous functionality / remote control

Fully autonomous

Degree of autonomy

30% of all cargo that is transported by truck over 300 km to be transported by waterways & rail within 2030 and 50% by 2050

European Commission, 2011

ASKO project;

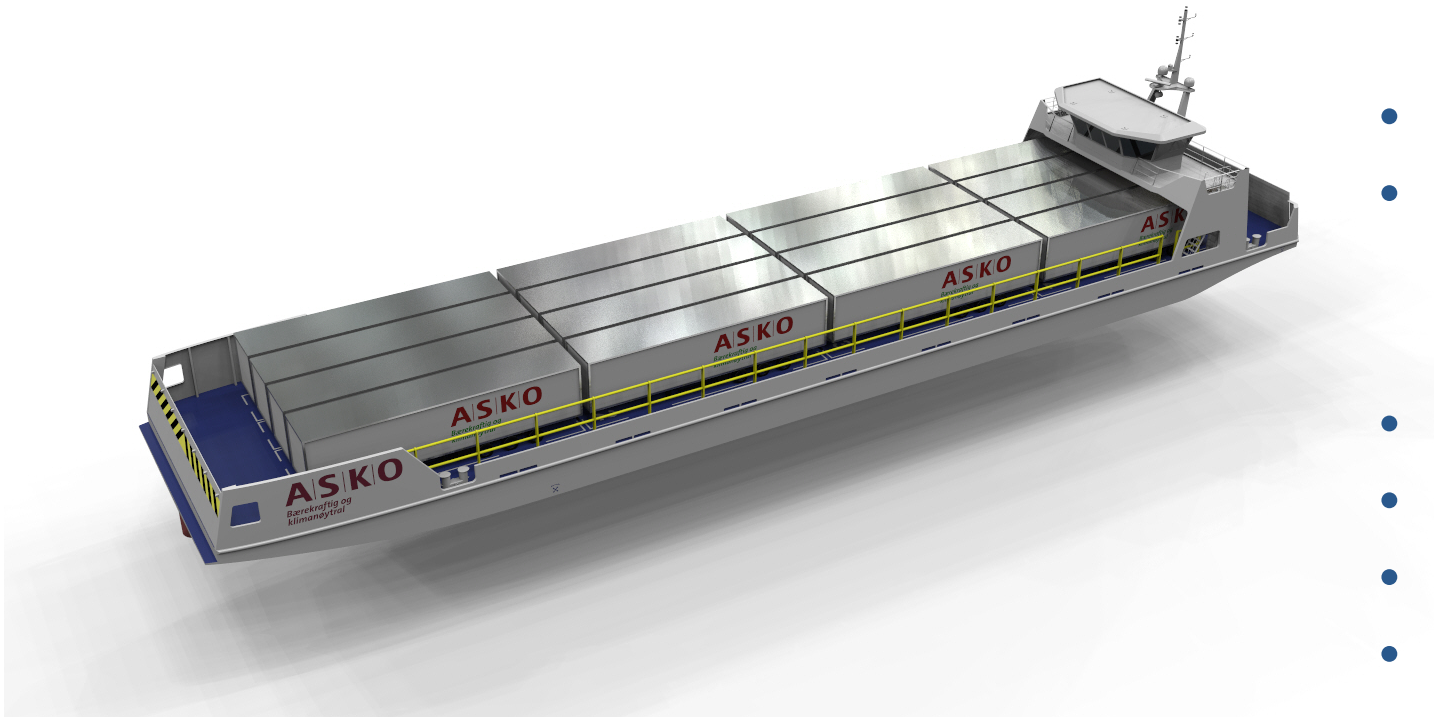
- Zero emissions transport with autonomous fjord crossing

ASKO project;

- Zero emissions transport with autonomous fjord crossing

ASKO project;

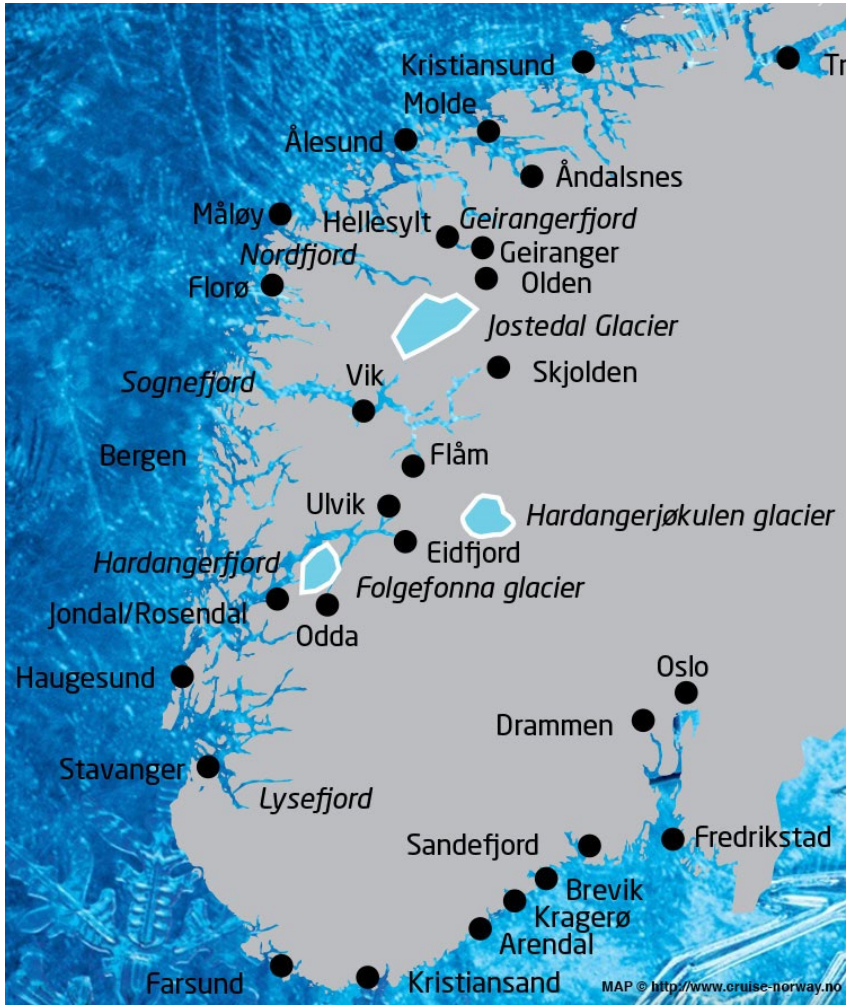
- Two fully electric autonomous RoRo feeders for 16 trailers



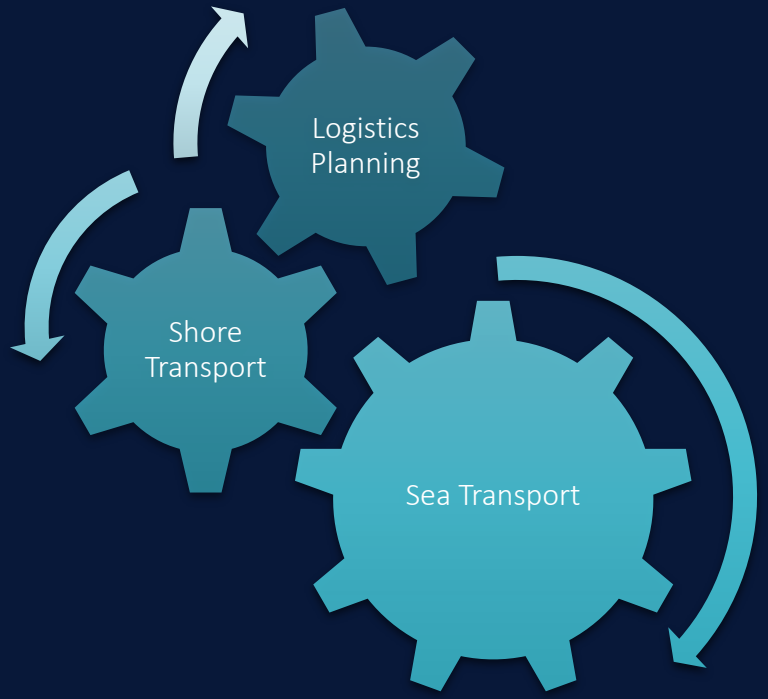
- Sailing between Moss, Holmestrand and Langøya (NOAH)
- Replacing 150 trucks daily
- CO2 emissions reduced by 5,000 tons / year

- Length: 66 m
- Width: 15 m
- Service speed: 8 knots
- Battery capacity: 1,7 MWh
- Target delivery: 2021/22
- Fully autonomous: 2024

Many geographical areas are suitable for this logistics solution



Collaboration is Key



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Feel free to contact us for more information

Name: Tom eystø

Title: CEO

Email: tom.eystoe@massterly.com

Mobile: +47 95 88 51 23