INTRODUCTION TO AUTONOMOUS SHIPS IN TRONDHEIM

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SINTEF Ocean

From January 2017, a merger of:

- MARINTEK
- SINTEF Fisheries and Aquaculture
- SINTEF Environmental Chemistry

Not-for-profit, independent

Contract research

360 employees

Scandinavia's largest independent research organization

USD 390 million
Revenues

USD 60 million
International sales

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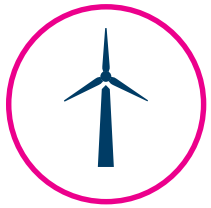
Applied research, technology and innovation

Expertise from ocean space to outer space:



Renewable energy

Ocean space

Industry

Buildings and infrastructure

Materials

Micro-, nano- and biotechnology

Climate and environment

Oil and gas

Health and welfare

Society

Digitalization

Transport

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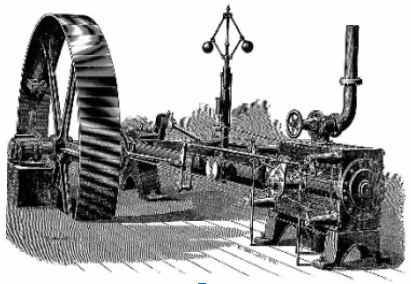
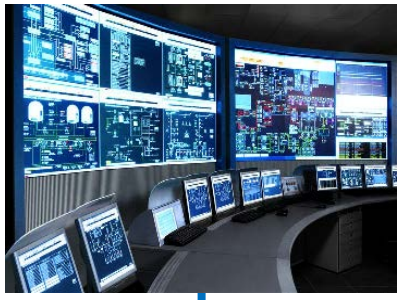
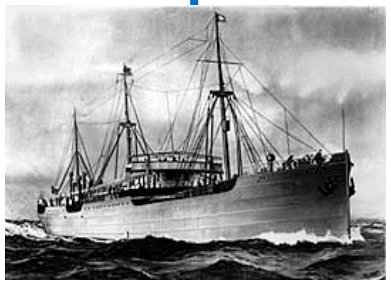
The fourth shipping revolution is on





1800 **1900** **1970** **2010**



1. Mechanized Power

2. Mass Production

3. Computerized Control

4. Shipping 4.0

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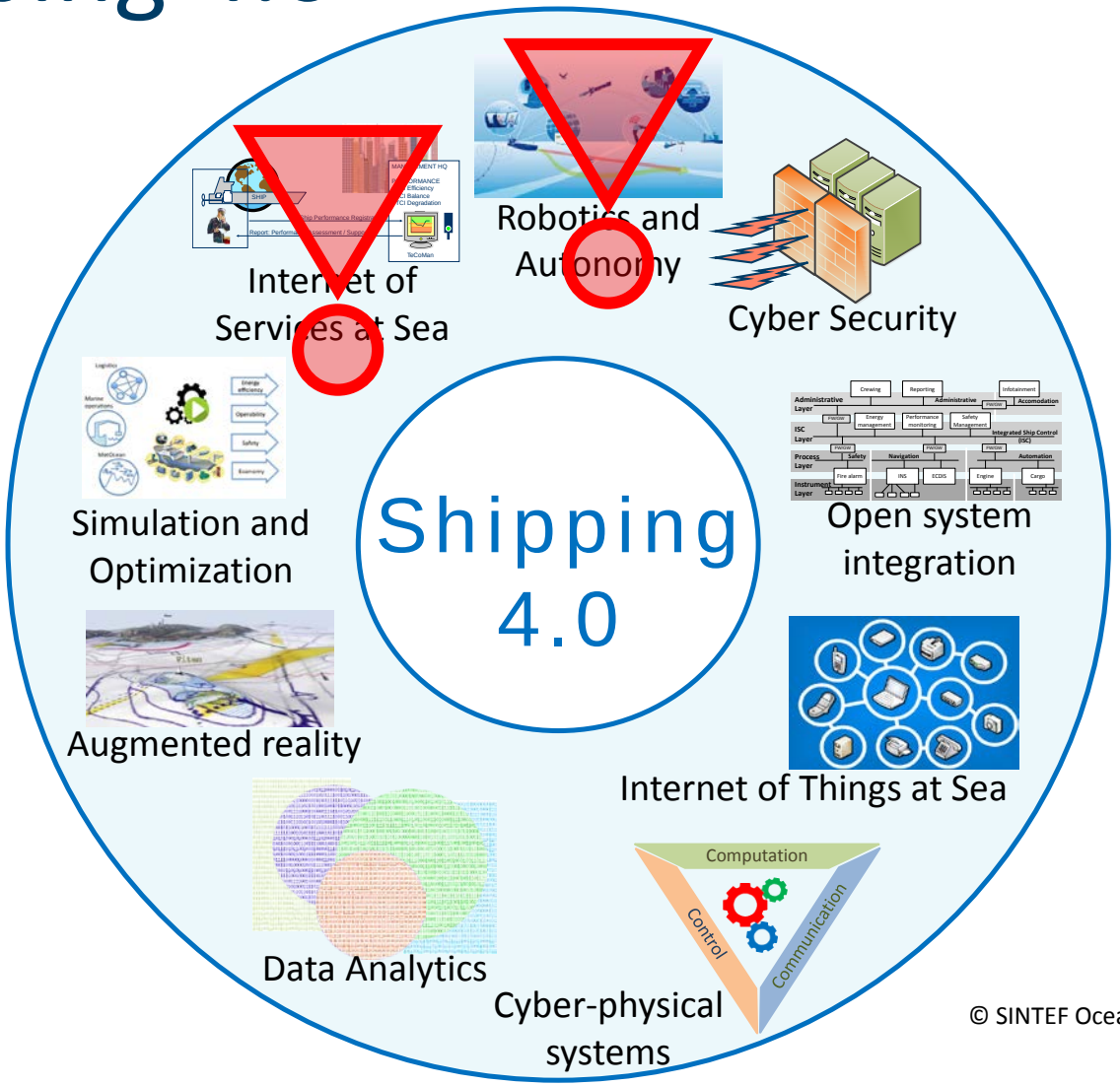
Shipping 4.0



Possible **game changers** in Shipping 4.0:

- Digitalization of commercial shipping processes
- Autonomous and unmanned ships

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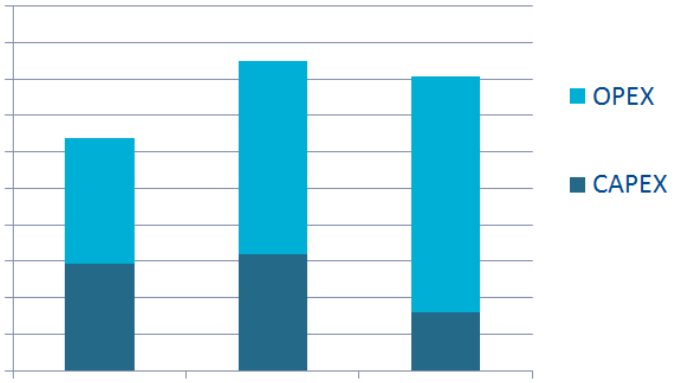
Autonomous ships in Norway

Why autonomous ships ?

Less dangerous exposure for crew

Less damage related costs

Fewer large oil spills



Lower costs ?

Lower emissions

New ship types

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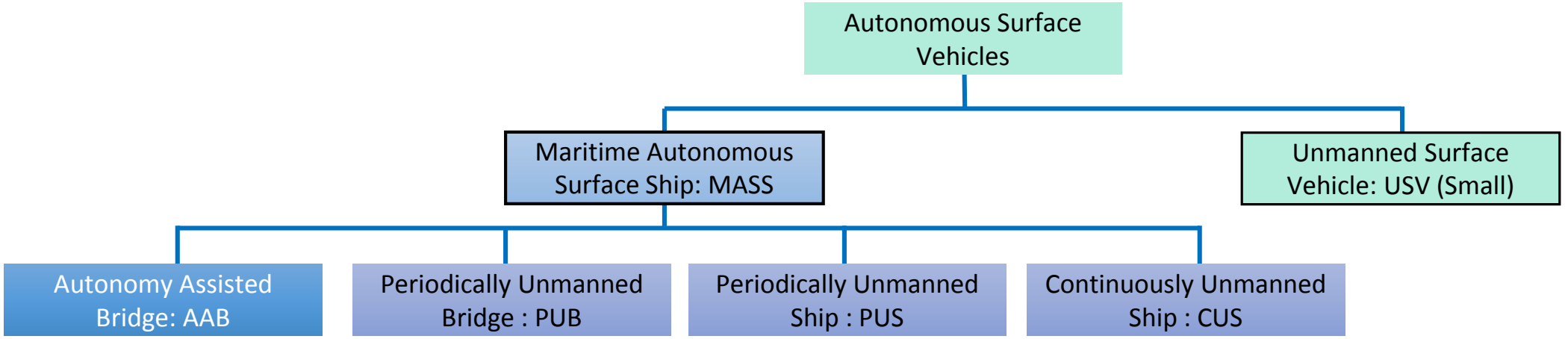
Types of autonomous ships – manning levels



Ship type	Always on Bridge	Available on Ship	Never on Bridge
AAB	x		
PUB		x	
PUS			x
CUS			x

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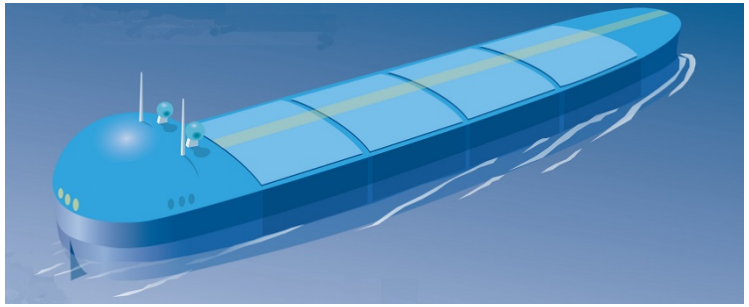
Completely unmanned gives largest benefits!



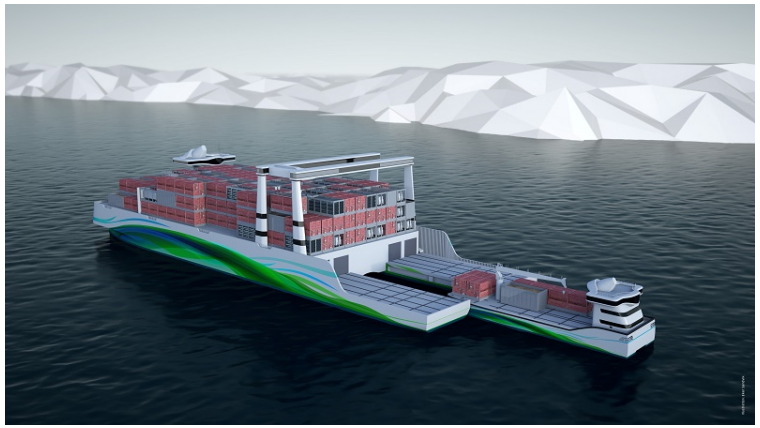
No accommodation

Less power

More cargo

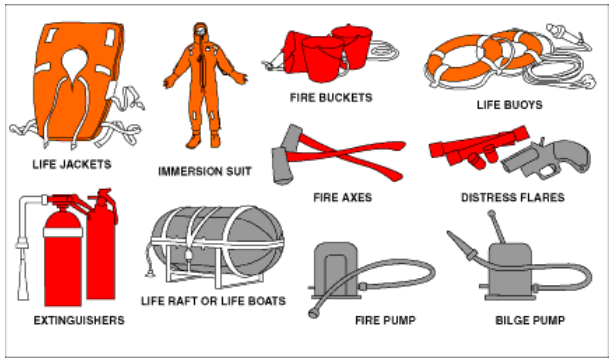
No crew

No crew related costs



NCE Maritime Clean Tech & NCL

Enables completely new ship concepts



No safety equipment

New constructions

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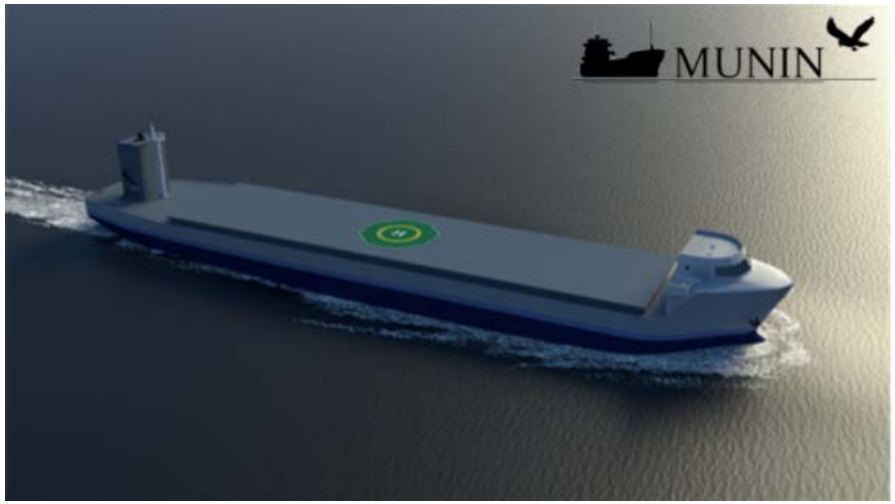
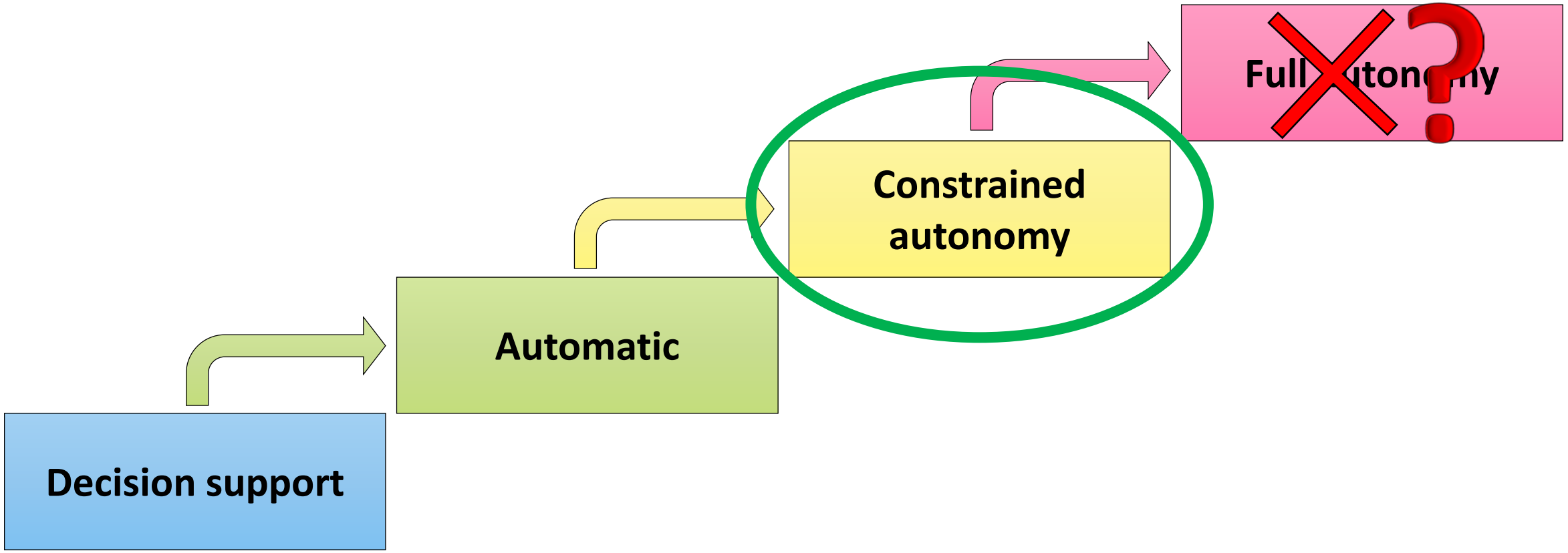
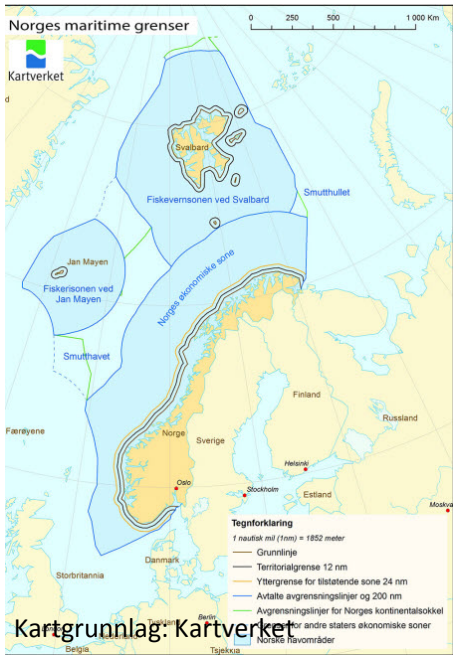
A Shore Control Centre (SCC) is normally needed



Operational autonomy levels



Why Norway?



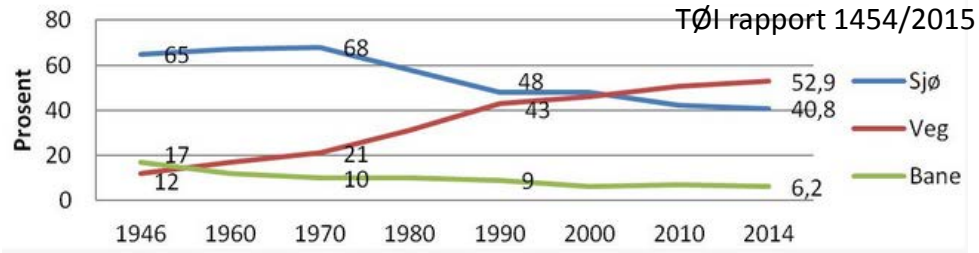
Kartgrunnlag: Kartverket

Coast: 100 000 km
Mainland: 85 000 km
Sea border: 2650 km

A complete maritime cluster.

Maritim Verdiskapingsbok 2015, Maritimt Forum, Norge

14% of value creation from businesses
38 % of export (ex HC)



TØI rapport 1454/2015

Still a big role in inland cargo transport – that needs to be increased

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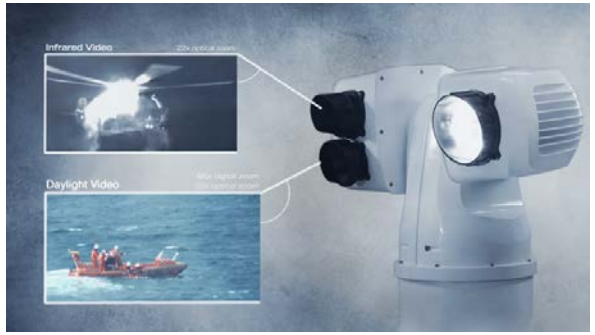
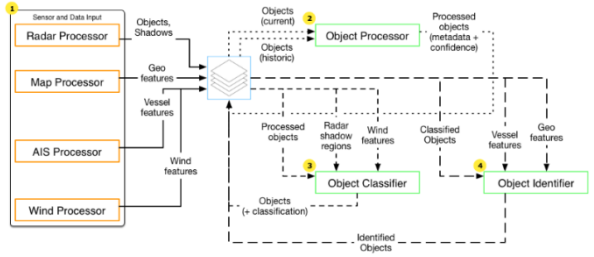
Why not unmanned ships?

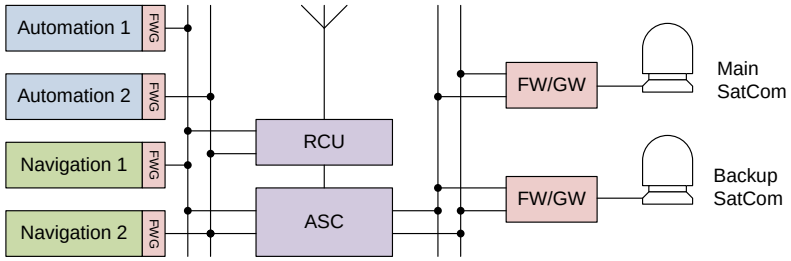
More advanced and expensive control systems



New detectors in IR and daylight video.
Improved radars.



Sensor fusion and classification: AIS, Radar and video.



General ship system redundancy and communication systems integration.

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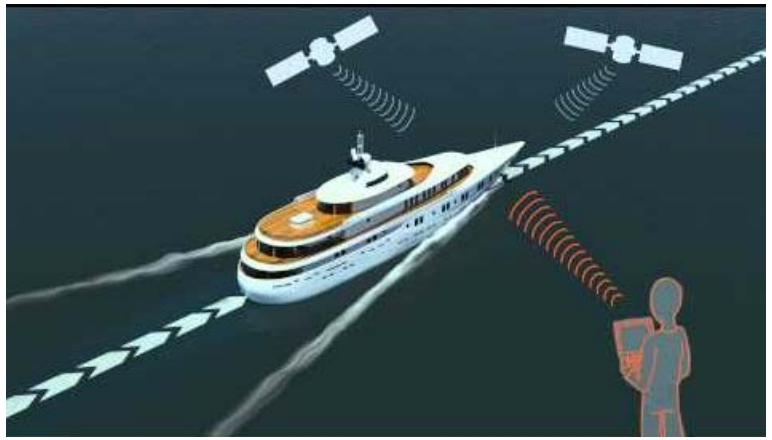
Hostile (cyber) attacks

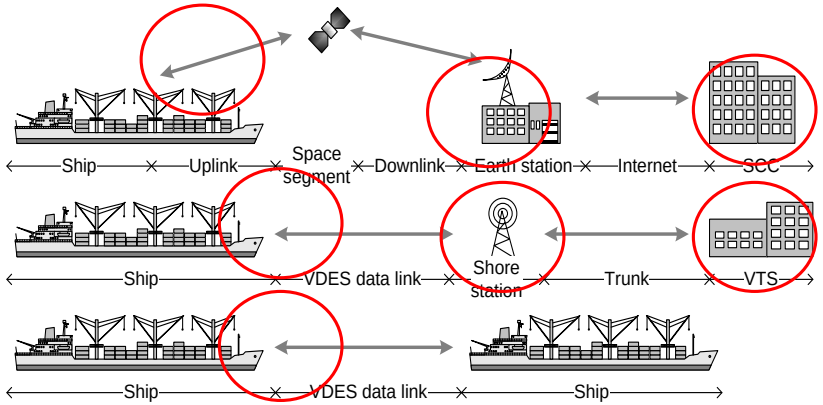
- Pirate attack

IMO

- Terrorist hijack e.g. by GPS spoofing



University of Texas at Austin



- Communication system attacks

- Governmental backdoor

Wikimedia.org/Caricato da Makki98

No one to ransom, difficult to steal
Stowaways is a problem!

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Legal and liability issues

- UNCLOS
- SOLAS

- Contracts

Easier to do this in national waters.

- Insurance
- Liability

wikimedia.org/paolodefalco75

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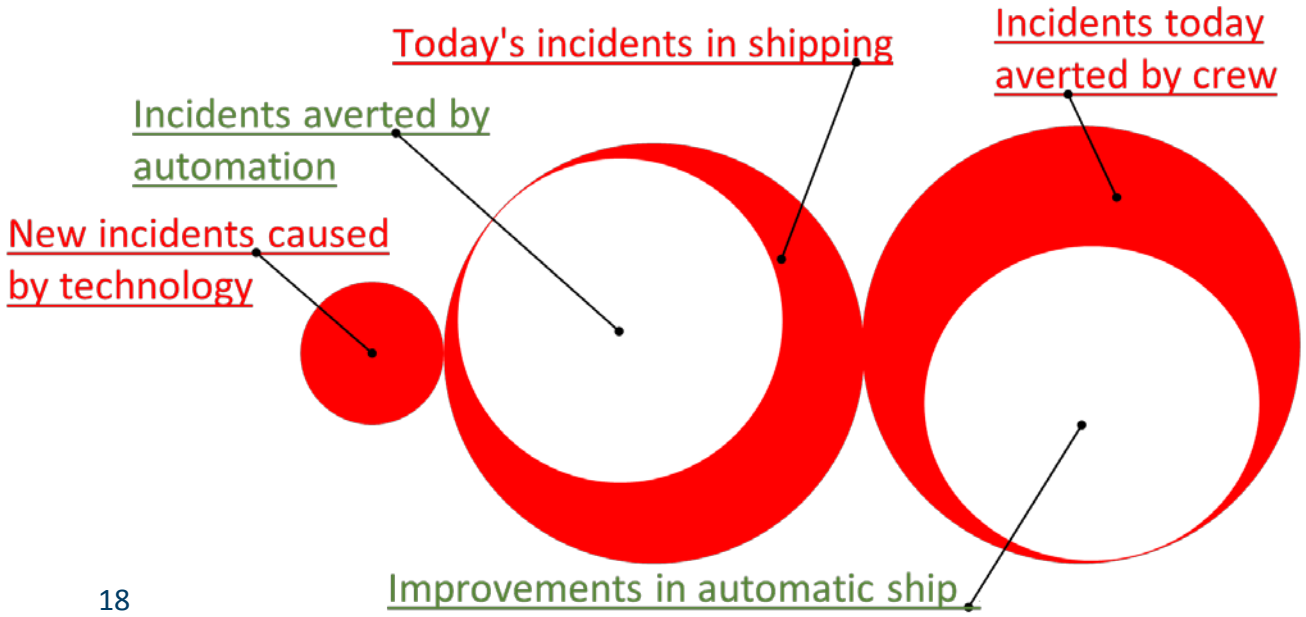
"Autonomy assisted accidents"

First radar assisted collision: Andrea Doria and Stockholm off Nantucket in 1956



Some new accidents are probably unavoidable. Question is the totality!

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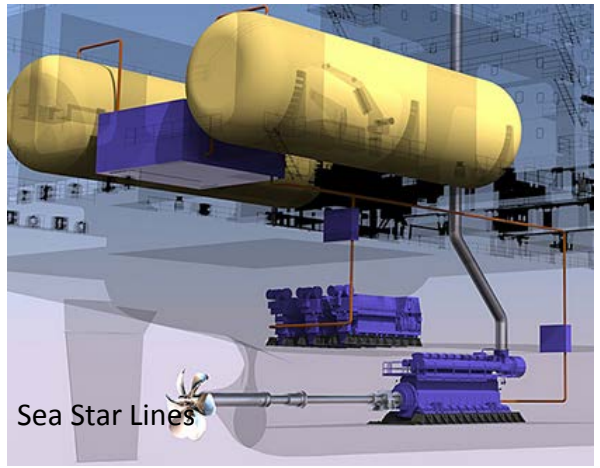
No maintenance on board

Redundancy

Minimize systems onboard



No heavy fuel oil

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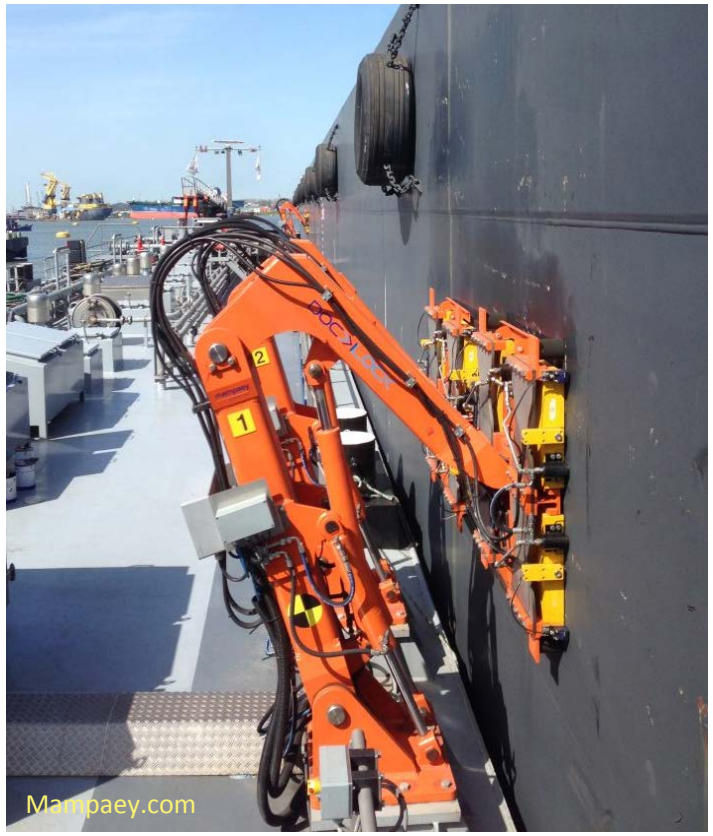
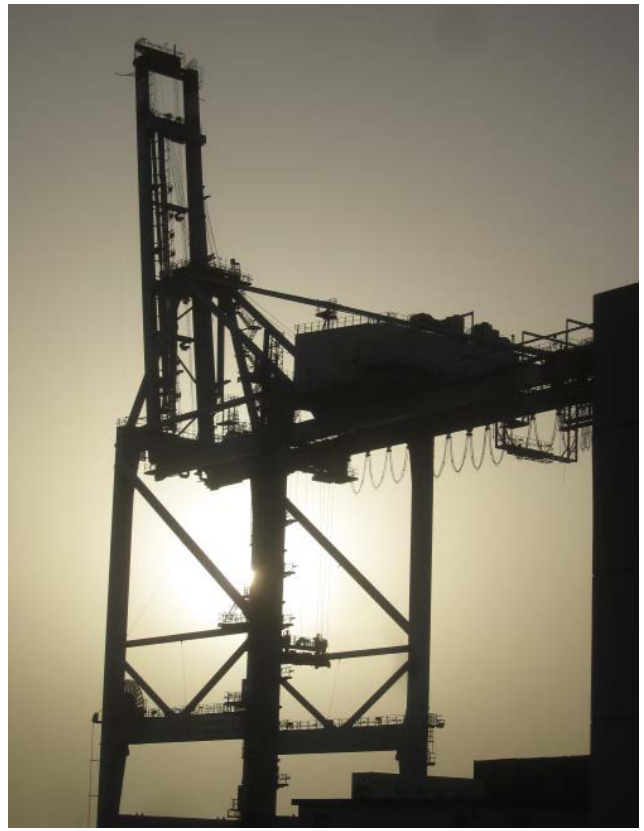
New infrastructure on shore

Shore control, VTS interface



Tugs, docking, mooring



Loading and discharge of cargo

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Cost-benefit

- No hotel
- No crew
- Improved efficiency
- Less off-hire
- New business model

- Dual propulsion, no HFO
- Shore Control Centre
- Longer dockings
- Costlier instruments
- Existing business model

So, what is going on?

MUNIN: A concept study for a fully unmanned handymax dry bulk carrier on intercontinental voyage.

- Duration: 01.09-2012 – 31.08.2015
- Funding: 2.9 million EUR of budget 3.8 million EUR
- Activity code: SST.2012.5.2-5: E-guided vessels - the 'autonomous' ship

http://www.unmanned-ship.org/munin/

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NTNU AMOS

NTNU AMOS
Centre for Autonomous Marine Operations and Systems

- Supported by Norwegian Research Council
- Norwegian "Centre of Excellence"
- Established 2013
- Planned for 10 years
- Total budget approx. EUR 80 million

https://www.ntnu.edu/amos

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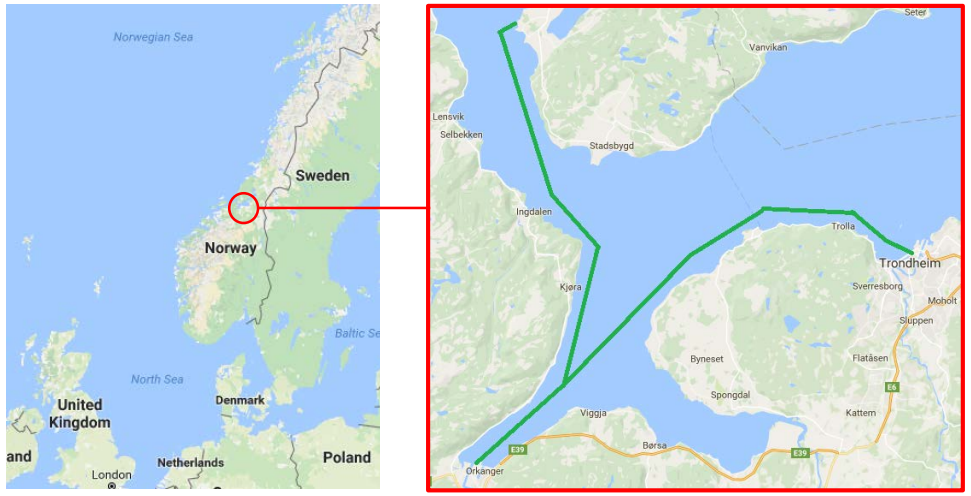
Test area Trondheimsfjorden



- Established September 30th 2016
  - Industry, university, research
  - Port of Trondheim
  - Norwegian Maritime Administration
  - Norwegian Coastal Administration
- Area covers Trondheimsfjorden
  - Permits
  - Instrumentation and communication
  - Exchange of experience

http://navtar.no/

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Norwegian Forum for Autonomous Ships

- Established October 4th 2016
- Operated as a joint industry project at SINTEF Ocean.
- General Manager is Mr. Ørnulf Jan Rødseth.
- A board of governors overseeing operations. General assembly approves budgets and strategies.
- 40 Institutional Members
  - Including Industry, authorities, class, insurance research, universities, ports …
  - 2 other institutions as personal members

NFAS Norsk Forum for Autonome Skip

http://nfas.autonomous-ship.org

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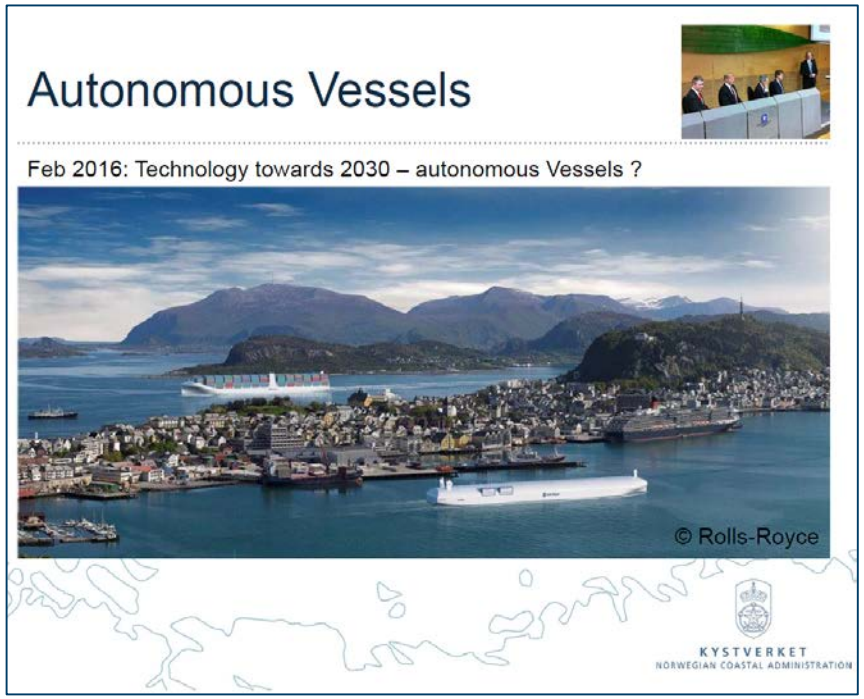
Norwegian authorities are positive



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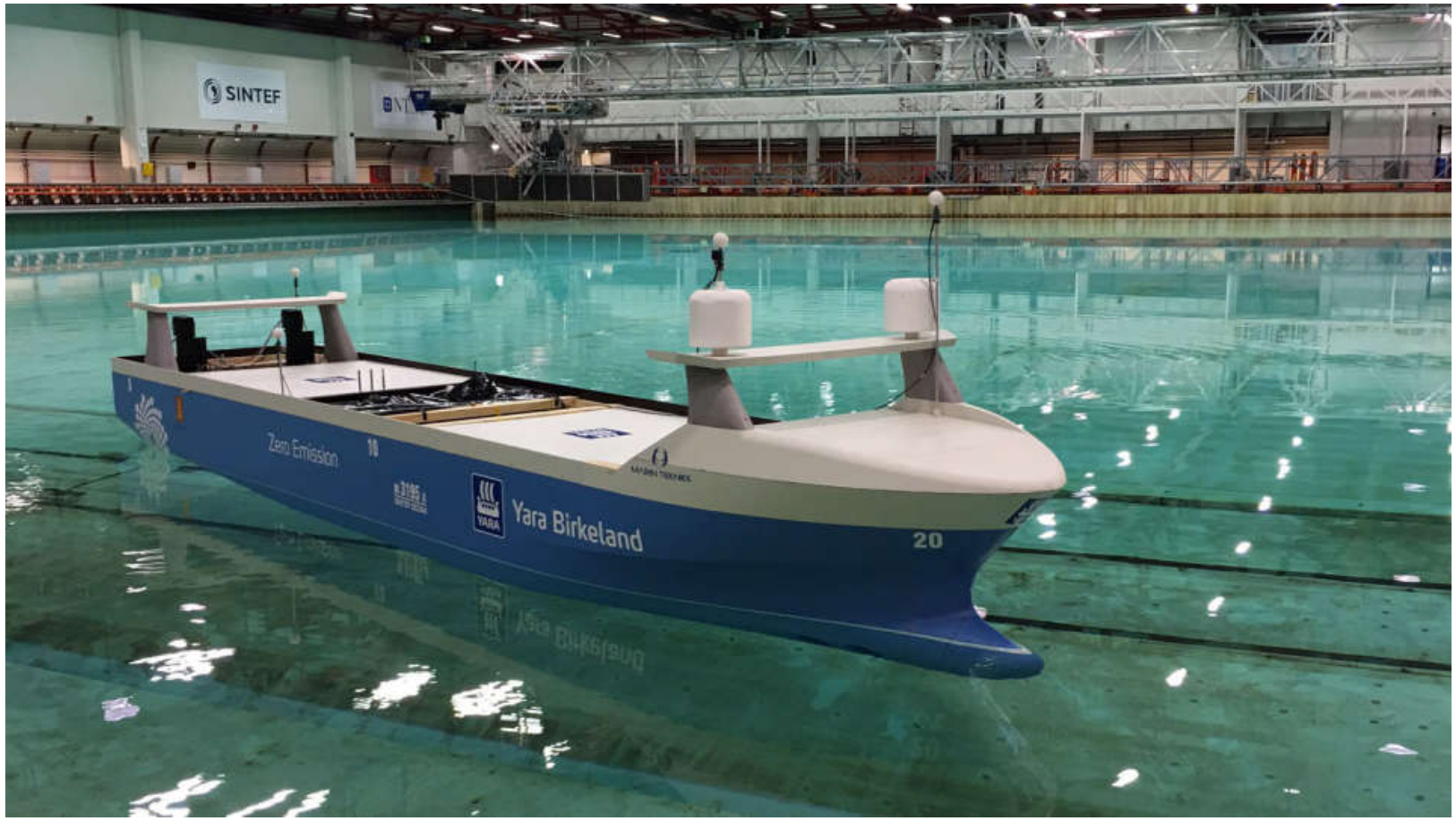
Some ongoing projects

Yara Birkeland



- Yara fertilizer
- Kongsberg partner
- Replaces 40 000 truck trips a year

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Autonomous Ship Transport at Trondheimsfjorden (ASTAT)

- Short voyages
- 12-50 TEU
- Inland, fjords/sheltered
- Low cost: Wait in port
- Legs 4-12 hours
- Port cranes
- Automated berthing
- Batteries

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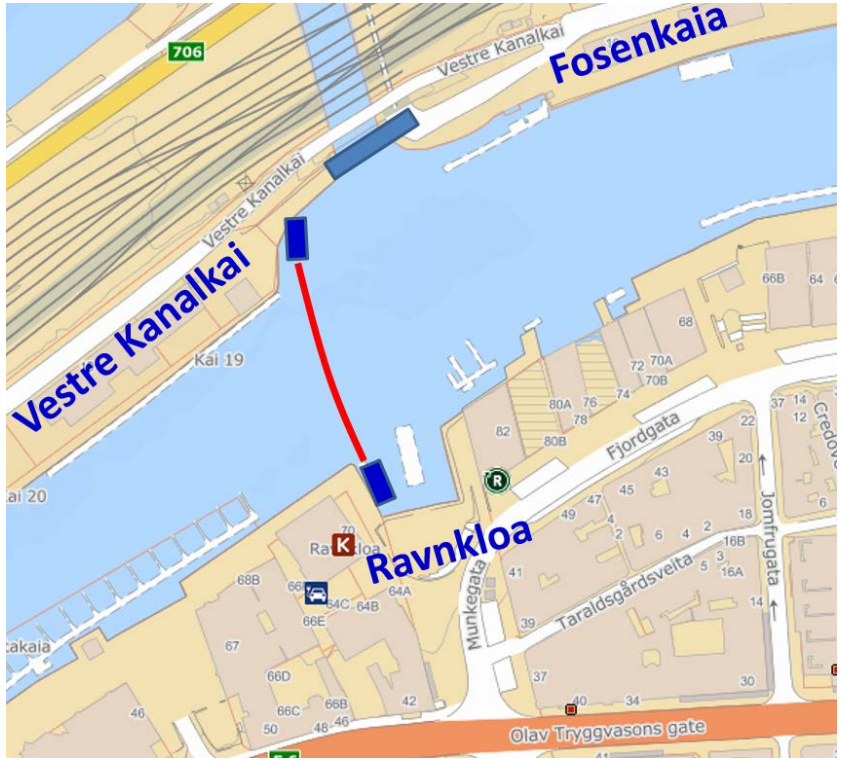
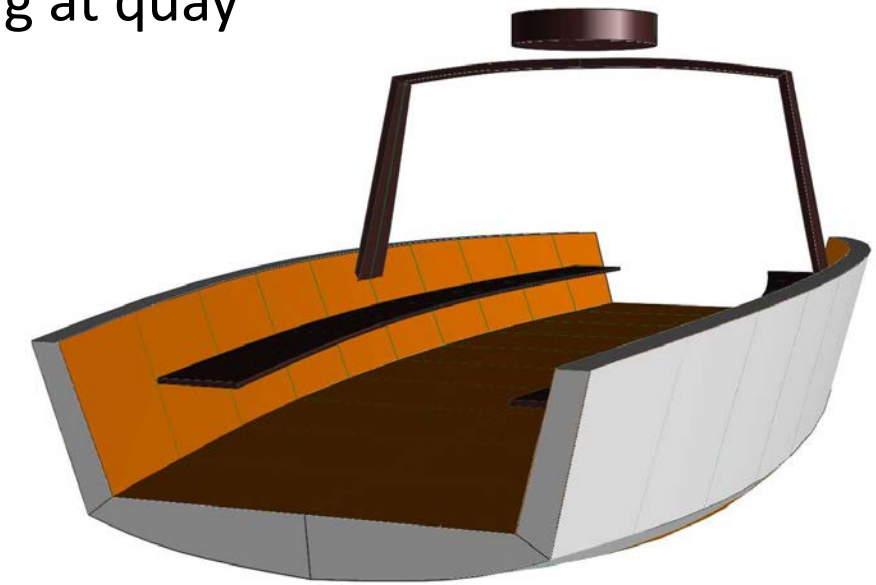
Milli-Ampere

NTNU
Kunnskap for en bedre verden

NTNU AMOS
Centre for Autonomous Marine Operations and Systems

- On-demand passenger ferry
- Max 12 persons + bicycles
- Electrical propulsion, battery
- Inductive charging at quay





Linking center of Trondheim to seaside and rail station

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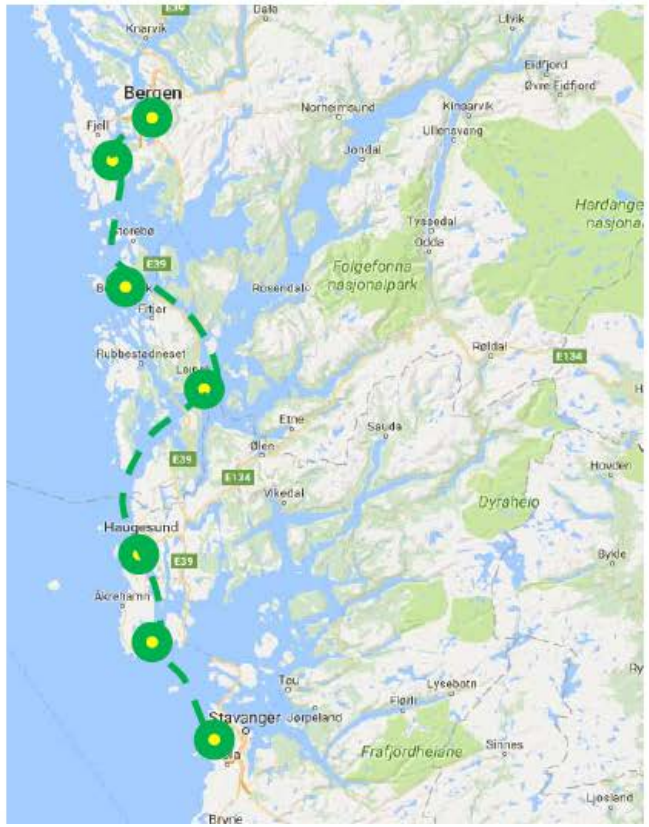
GREEN COASTAL SHIPPING PROGRAMME

Pilot 8: AUTONOMOUS COASTAL CONTAINER FEEDER

KONGSBERG

Operational area



Vessel

Plug in hybrid.
Battery powered during normal operation.
Speed: 12 kts
Operational range: 100nm
Capacity: 100 TEU
1300 DWT
LOA: 60 m

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Hrönn: Unmanned offshore vessel

BOURBON AUTOMATED SHIPS LTD KONGSBERG

- Light-duty, offshore utility ship
- Commissioned in 2017, in operation 2018
- Initially for man in the loop applications
- Tested in Trondjemsfjorden test area

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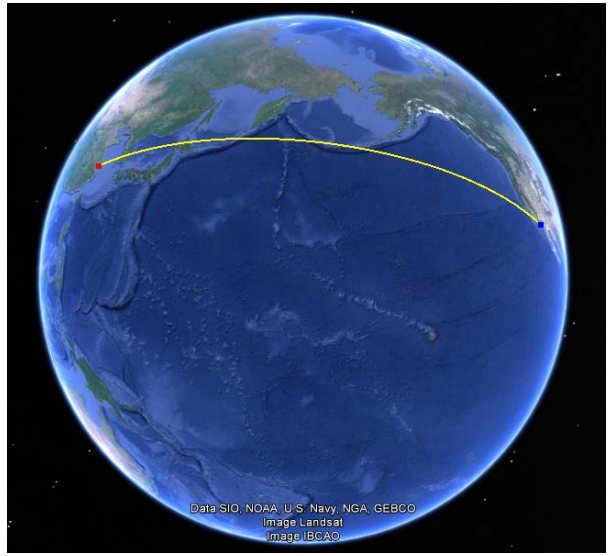
Deep sea is feasible, but not first mover ?

- 10 000 TEU container vessel
- Shanghai – Los Angles
  - Two states involved
  - 6000 nm, open sea
  - No channels
  - Short port approach
  - Remote control to port
- Dual propulsion systems
- Two stroke diesels
- Biofuel, methanol …



… but, autonomous ships are <u>not</u> conventional ships without crew.

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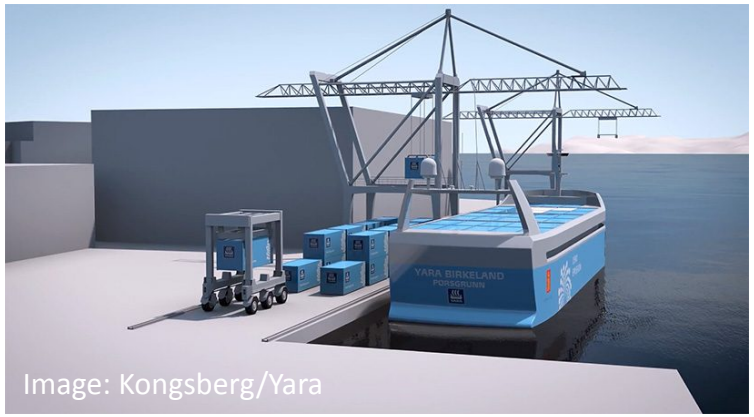
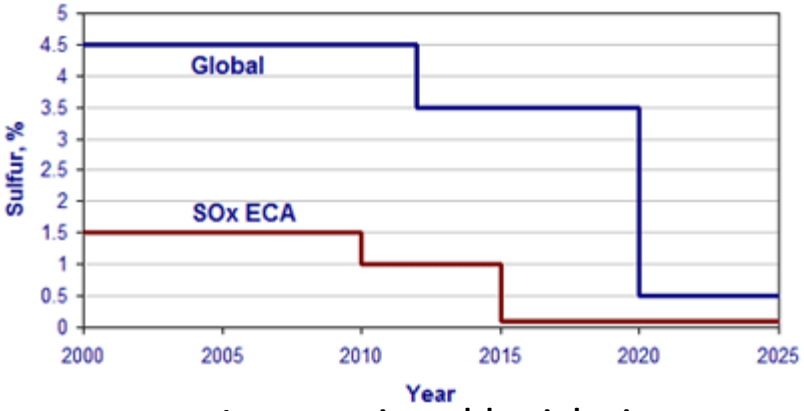
External factors may help !

Subsidies: NOx-fund



Public infrastructure investments



International legislation

Regional restrictions: HFO in Arctic

Member
Green Business Certified

Green businesses

Black swans: Cost of new energy carriers

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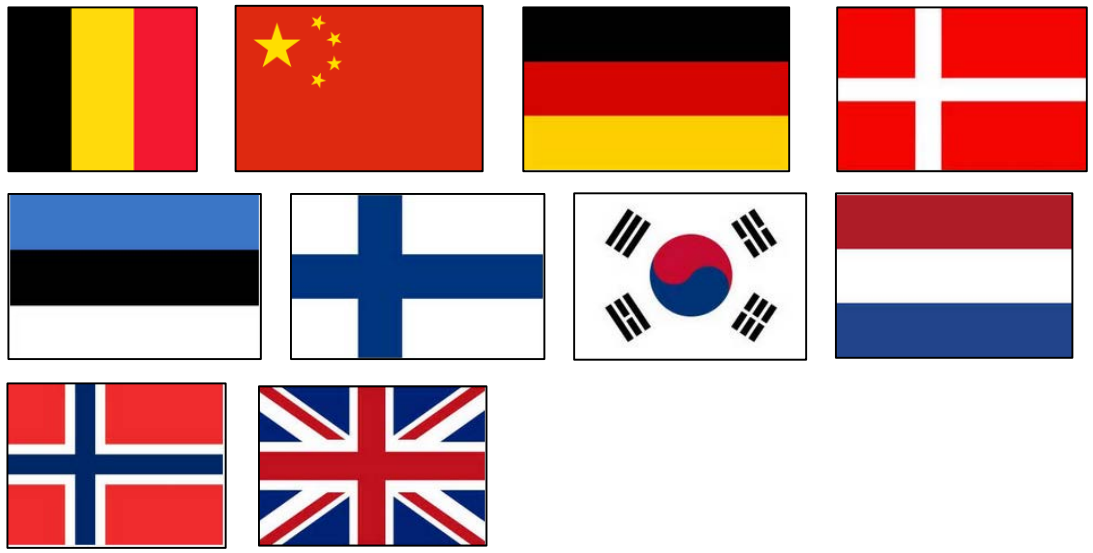
International activities

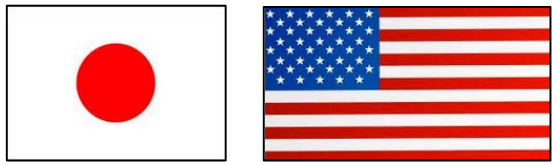
National and international strategy

International Forum for Autonomous Ships

- Agreed on at meeting in Oslo Oct. 30th 2017
- Hosted by NFAS and SINTEF Ocean
- 22 participants at meeting



- Two more correspondents



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Bilateral agreements

Research project on test area development

- April 1st 2017 to December 31st 2019
- SINTEF Ocean + KMOU + ETRI
- Funded by Korea

Memorandum of Understanding signed 21st October 2017:

- Conference Of Great Lakes And St. Lawrence Governors And Premiers
- The Marine Autonomy Coalition
- NFAS

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Conclusions

- Shipping 4.0 is possible game changer in autonomy and digitalization.
- Autonomous ships is an important strategic area in Norway and SINTEF Ocean.
- Unmanned ships are “constrained autonomous”
- International cooperation is required and ongoing!

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Technology for a better society