



## Norwegian Forum for Autonomous Ships

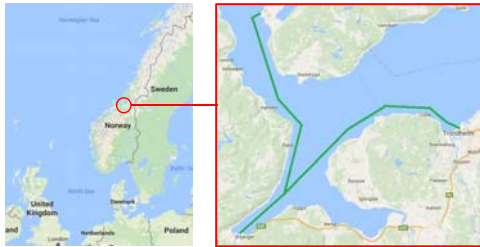
- Established October 4th 2016
- Operated as a joint industry project at SINTEF Ocean.
- General Manager is Mr. Ørnulf Jan Rødseth.
- A board of governors overseeing operations. General assembly approves budgets and strategies.
- 42 Institutional Members
  - Including Industry, authorities, class, insurance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

**NFAS** Norsk Forum for  
Autonome Skip

<http://nfas.autonomous-ship.org>

**SINTEF**

## 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/>



Some ongoing projects



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

**NTNU**  
Kunnskap for en bedre verden

**NTNU AMOS**  
Centre for Autonomous Marine  
Operations and Systems



Linking center of Trondheim to  
seaside and rail station

**SINTEF**

## Yara Birkeland

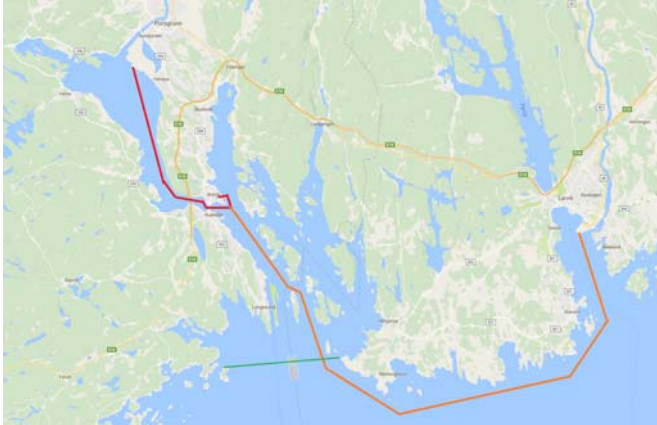


- Yara fertilizer
- Kongsberg partner
- Replaces 40 000  
truck trips a year

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**SINTEF**

## Yara Birkeland Operation



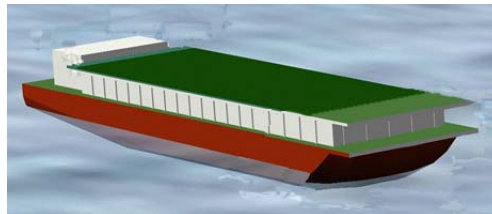
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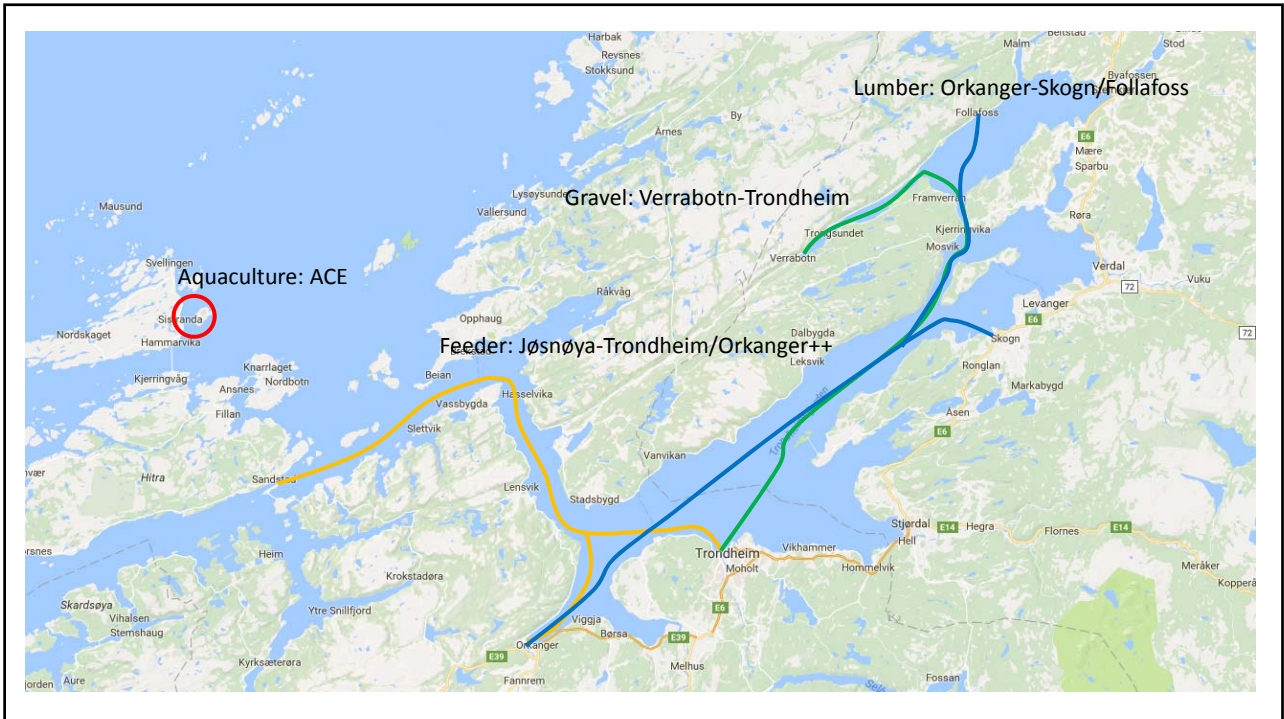
- Features
  - 100-150 TEU, 70 m x 15 m
  - Batteries – Fully electrical
- Staged implementation
  - Manned after 1 year
  - Remote after 2 year
  - Autonomous after 3 year
- Operational area
  - Herøya-Brevik – 7 nm
  - Herøya-Larvik – 30 nm
  - Within Brevik VTS area



## 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

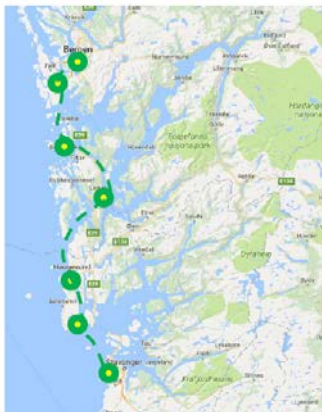




# GREEN COASTAL SHIPPING PROGRAMME

Pilot 8: AUTONOMOUS COASTAL CONTAINER FEEDER

## 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



KONGSBERG

## Grønn: Unmanned offshore vessel



- 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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Why autonomous ships ?

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# Why unmanned and autonomous ships?



Wikimedia Commons

Less dangerous exposure for crew



Sjøfartsdirektoratet

Remove bad working conditions



MAIB, UK

Less damage related costs



Exxon Valdez Oil Spill Trustee Council

Fewer large oil spills



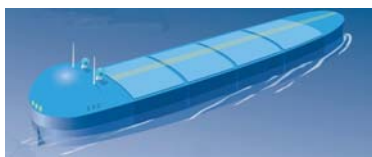
Lower emissions



New ship types



# Completely unmanned gives largest benefits!



No accommodation  
Less power  
More cargo



No crew  
No crew related costs



NCE Maritime Clean Tech & NCL

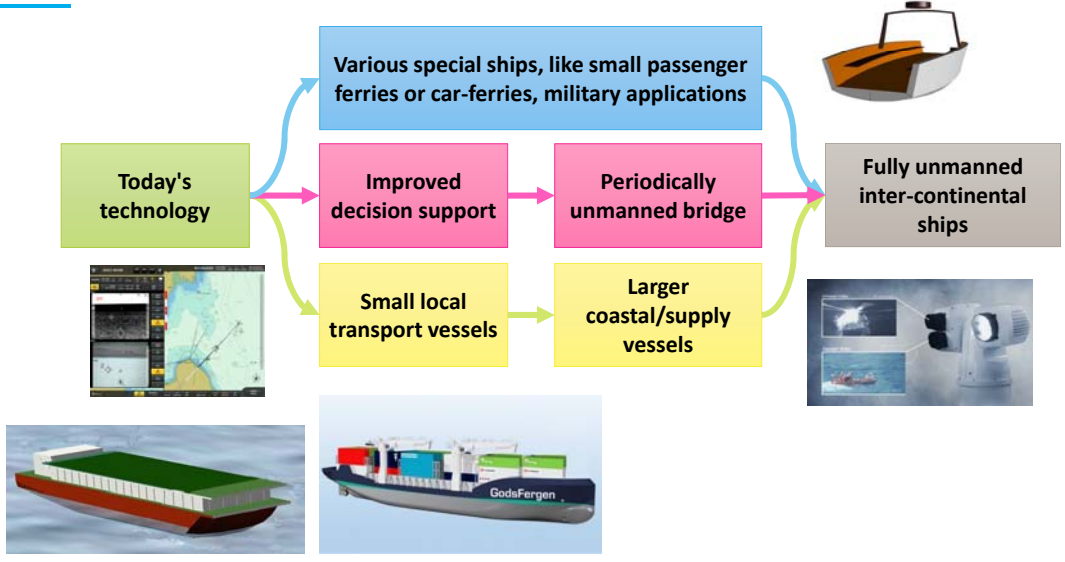
Enables completely new ship concepts



No safety equipment  
Other approaches to safety



# Developments towards unmanned ships



# Commercial differences between cars and ships



Large high-value assets



Exxon Valdez Oil Spill Trustee Council  
Accidents have very high damage potential



Vard AS  
A ship is normally one-off



Relatively few ships in the world





## Operational differences between cars and ships



Things move slower



Things are bigger



More space, less obstacles



Kongsberg



Kystverket



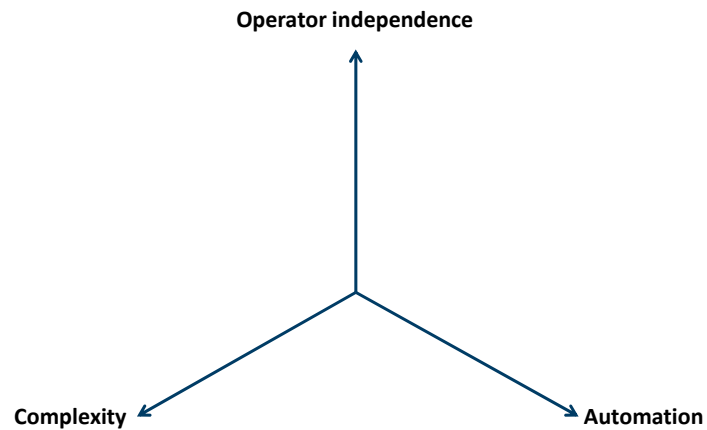
Kystverket

Advanced technology already in place



What is "autonomous" for a ship ?

## Autonomy is a function of several factors



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## With, e.g. six levels on each axes

Level	Operator independence	Automation	Complexity
0	Crew at bridge at all times	None: Direct control by human.	Few static obstacles.
1	Periodically unmanned bridge monitored by shore control that can muster crew on ship	Guidance to operator, no automatic control	Many static obstacles.
2	Unmanned ship, continuous shore monitoring and control	Human supervises, automatic and deterministic control using simple set-points	Some movements of obstacles, no restriction on ship manoeuvrability.
3	Periodically unmanned bridge with no shore monitoring, crew on ship mustered by system	Fully automatic and deterministic longer and more complicated control sequences	Some movements of obstacles, some restriction on manoeuvrability.
4	Unmanned with shore monitoring, shore takes control when needed	Constrained autonomy – several, but restricted options selected by ship control system	Many movements, some restrictions on manoeuvrability.
5	Unmanned, no shore monitoring or control	Fully autonomous – no restrictions on decisions by system.	Many movements, significant restrictions on manoeuvrability.

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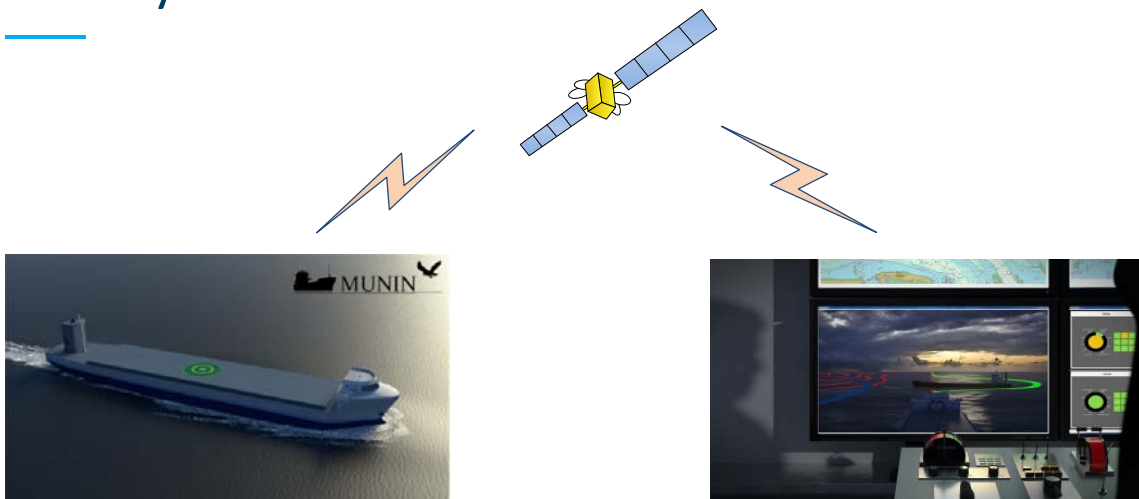


## Ship autonomy types expected by NFAS

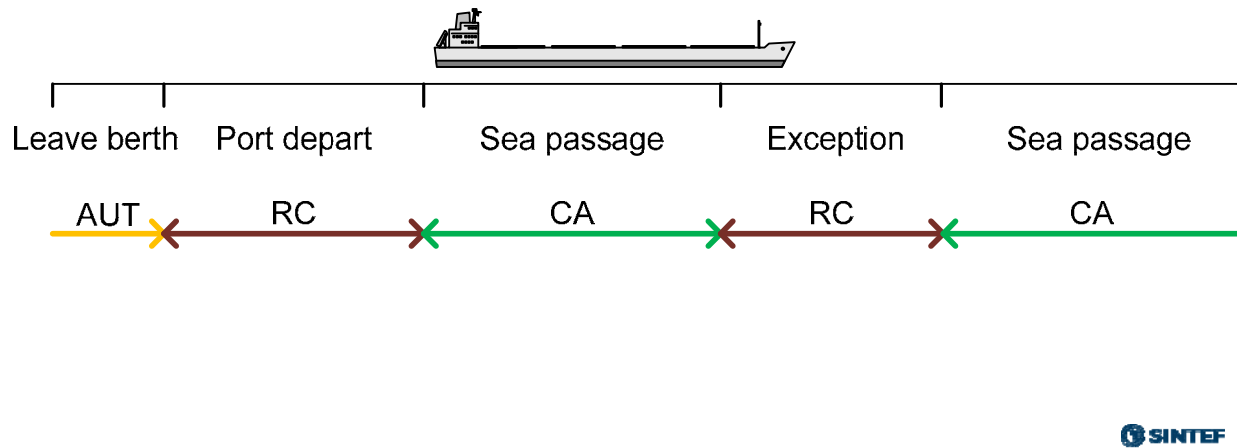
- ✓ **1. Direct control:** Minimal automation and decision support
- ✓ **2. Decision support:** Decision support and advice to crew on bridge. Crew decides.
- ✓ **3. Automatic bridge:** Automated operation, but under continuous supervision by crew.
- ✓! **4. Periodically unmanned:** Supervised by shore. Muster crew if necessary.
- ! **5. Remote control:** Unmanned, continuously monitored and direct control from shore.
- ! **6. Automatic:** Unmanned under automatic control, supervised by shore.
- ! **7. Constrained autonomous:** Unmanned, partly autonomous, supervised by shore.
- ✗ **8. Fully autonomous:** Unmanned and without supervision.



## "Always" a shore control centre !

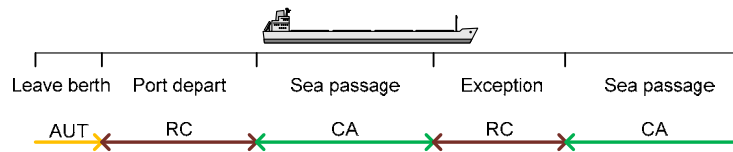
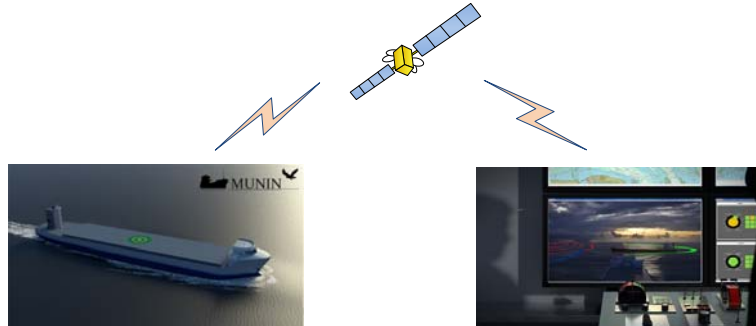



## Different types of autonomy in different phases

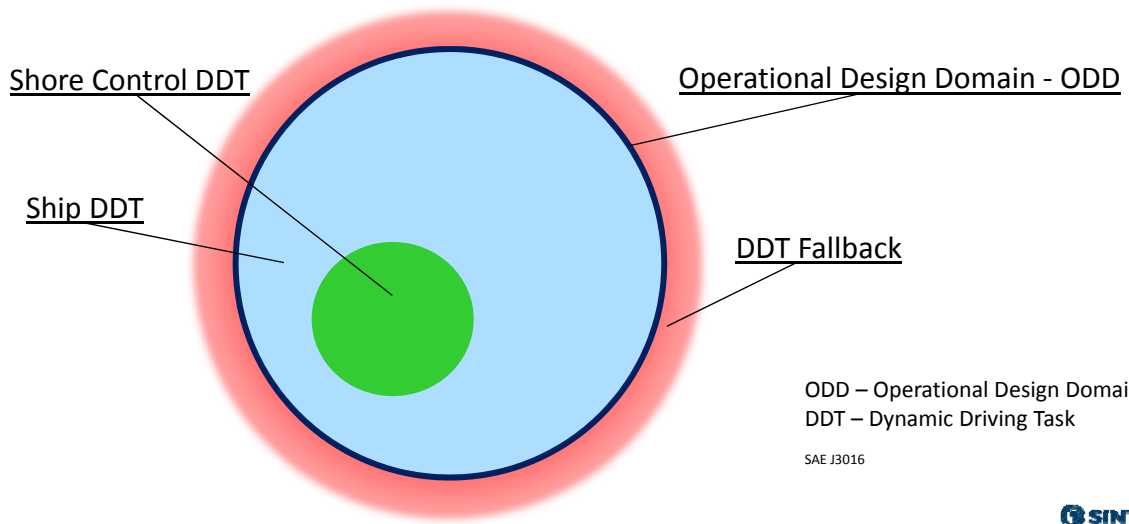


Some human factor issues for unmanned ships

# Operation of Shore Control Centre



# Allocation of responsibility



## Integration with other shore services



Kongsberg/Yara

- VTS, pilots
- Locks, bridges
- Ports and port operations
- Search and Rescue

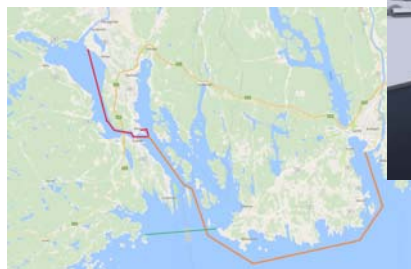


## Manned vessels' reactions to unmanned ships



Rolls Royce

Convoy operations



Kongsberg/Yara

Other ships



NTNU/Flickr

Leisure and fisheries crafts



## Passenger safety



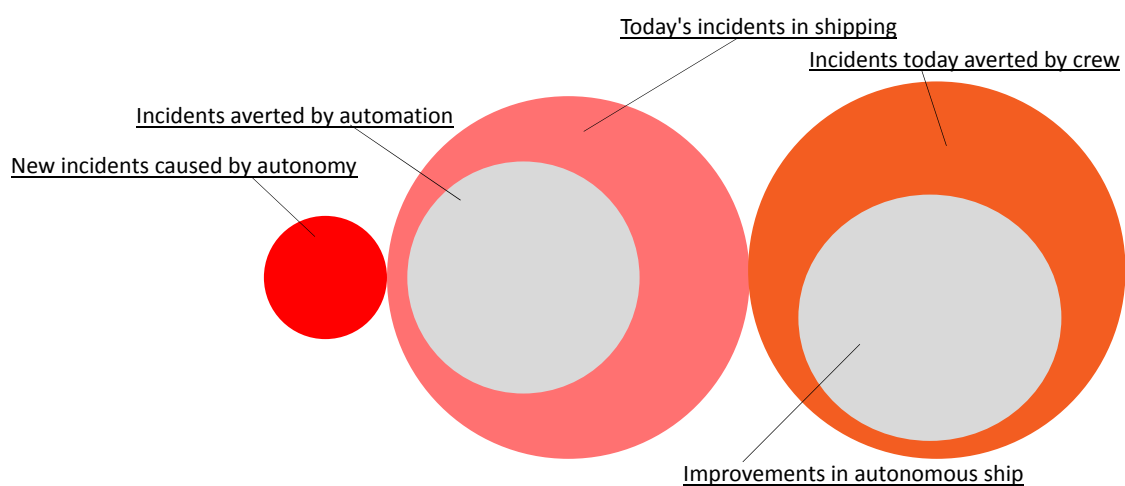
Small on-demand passenger ferries



Unmanned car ferries  
 - Adjust capacity to demand  
 - On-demand



## Risk levels



## Conclusions

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- Fully autonomous and unmanned ships can be disruptive to shipping.
- Several projects already under way, but still in design phase.
- Autonomous ships are not quite like autonomous cars: Somewhat different approach to autonomy.
- Human factor issues may have more overlap with other sectors, many different aspects.

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Technology for a better society