DNV GL’s research within Autonomous Systems

Nor-Shipping workshop: Professional Insight on Unmanned Ships
DNV GL in brief
Industry consolidation

[Image showing the logos of DNV GL and its partners: GL Group, KEMA, Noble Denton, Garrad Hassan, Advantica]
Global reach – local competence

150 years
400 offices
100 countries
16,000 employees
Organized to maximise customer value

MARITIME

OIL & GAS

ENERGY

BUSINESS ASSURANCE

SOFTWARE

CYBERNETICS

RESEARCH & INNOVATION
Strategic research & innovation programmes

OIL & GAS AND ENERGY SYSTEMS
- Offshore safety
- Safety and reliability of the subsea factory
- Energy foresight

ARCTIC TECHNOLOGY
- Arctic offshore structures
- Arctic ship structures
- Arctic oil spill preparedness

POWER SYSTEMS ELECTRIFICATION
- Super grid
- Smart grid
- Storage

INFORMATION TECHNOLOGY
- Autonomous systems
- Big data analytics of sensor data

MATERIALS
- Materials in energy storage
- Risk management of corrodbile systems
- Advanced materials and sensors

CLIMATE CHANGE
- Adaptation
- Mitigation

MARITIME TRANSPORT
- Safer shipping
- Greener shipping
- Smarter shipping

HEALTHCARE
- Patient safety

LOW CARBON FUTURE
- Renewable energy
- Green economy
- Transformation process
Autonomous Systems
Autonomous Systems - an emerging technology

- **Automotive Industry**
  - *Self-driving cars* are fast approaching
  - Major developments:
    - Google, GM, VAG, Mercedes, BMW, Nissan, Tesla ++

- **Subsea**
  - Autonomous Underwater Vehicles (AUVs)
  - Mature industry

- **Military**
  - Unmanned Arial Vehicles (UAVs)
  - Increasing level of autonomy
  - Autonomous ground and marine vehicles
Autonomous Systems in the Maritime Industry

- **Today**
  - Research projects
  - Question of WHEN, not IF

- **Motivation**
  - High accident and casualty rates in Maritime
  - Majority (~80%) caused by Human Errors
  - Autonomy may be key in reducing accidents

- **Not necessarily unmanned**
  - Assist human operation
  - Backbone identical
    - => difference: where it is connected in “the loop”
  - Key: Situation Awareness
Main drivers and barriers for autonomy in maritime

- Safety
- Basic tech development
- Qualified personnel availability
- Cost
- Autonomy in other sectors

- Liability
- Maintenance and repairs
- Handling the unexpected
- Regulatory
- Public Opinion
Our main research focus – understand the technology

- **Navigation Safety**
  - Collision and Grounding Avoidance
  - COLREGs compliance

- **Sensors and Situation Awareness**
  - Camera, Radar, AIS, Lidar, IR Camera
  - Sensor fusion and redundancy
  - Handle failures and false detections

- **Verification**
  - How to verify
  - Requirements for safe operation

- **The big picture**
  - How does autonomous systems fit into the maritime industry?
How we research autonomous systems for maritime

- Joint research projects with academia and industry:

  ![NTNU](image1) ![Kongsberg](image2) ![Rolls-Royce](image3) ![Maritime Robotics](image4)

- We operate autonomous prototype models

- Internal projects and concept studies, like the ReVolt
Background

- Bare tungtransport ødelegger norske veier

**To trailere og én vare**

E18
Population growth and freight demand

Large population growth in the urban regions: 30-40%, Larger growth in the transport work: 50-60%
(SSB/TØI, 2040)

<table>
<thead>
<tr>
<th>Region (region)</th>
<th>2012</th>
<th>2040</th>
<th>%</th>
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<tbody>
<tr>
<td>Stavanger</td>
<td>359,643</td>
<td>486,547</td>
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<td>Bergen</td>
<td>324,111</td>
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<td>Trondheim</td>
<td>215,954</td>
<td>279,741</td>
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Kilde: SSB
Governmental initiatives

- Transfer more freight from land to sea
- Increase the competitiveness
- High on the agenda in EU
Freight transfer potential

20000M ton kilometers

3800M ton kilometers

17

DNV GL © 2014
Status: Short sea shipping today

- Age average: 21.8 years (NIS/NOR)
- High fuel consumption
- High operational expenses
- High taxation level

Small margins
CO₂ emissions

**Ambition:**
60 % reduction in CO₂ emissions

900 million tonnes per year

Lives lost at sea

**Ambition:**
90 % reduction in fatalities in shipping

900 ship accident fatalities per year Average 2003-2012

Freight cost

**Ambition:**
Maintain or reduce present freight cost levels

7-11% of cargo value
## Operational profile

### AIS benchmark
- General cargo vessels represent 23.4% of the total number of ships.
- Speed: 8.7 kts
- Frequent port calls.
- Capacity: 107 TEU

### ReVolt
- Coastal traffic from Oslo to Trondheim
- Speed: 6 kts
- Operational range: 100nm
- Capacity: 100 TEU

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![Map of Norway](image_url)
Hull

Inclined keel – ballast free design

Increased load capacity

Straight bow

Inclined keel – ballast free design
Calm Water: 53 kW @ 6kts = Toyota Yaris
Average weather: 132 kW @ 6kts = BMW 5 Series
Propulsion system

- Twin screw
- Podded propulsion
- 2 bladed propellers
- 79% efficiency
- No cavitation
- Retractable bow thruster for manoeuvrability
Efficiencies

<table>
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<th>Battery</th>
<th>Hydrogen</th>
<th>LNG</th>
<th>MGO</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>η = 63%</td>
<td>η = 13.5%</td>
<td>η = 23.9%</td>
<td>η = 23.5%</td>
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</table>

100%
Battery Powered

Pros
- No direct emissions
- High efficiency (97%)
- Low maintenance
- Low OPEX
- Low C-rate

Cons
- High CAPEX
- Less proven technology

Required battery capacity:
- 2300 kWh average weather
- 5500 kWh including bad weather (97%)
Charging Infrastructure

- Charging on every port stay
- Average port stay duration of 4 hrs
- Low charge rate – long life (15 years)

- Combined with mooring system
- Infrastructure must be expanded
ReVolt Energy Requirements

ENERGY REQUIREMENT

TRUCKS 200X

CONVENTIONAL SHIPS 40X

ReVolt
Energy efficiency measures

- Solar panels
- Flettner rotors
- Sails
- Wave assisted propulsion
Automatic mooring

Vacuum based

Source: TTS

Grip arm

Source: TTS

Source: Cavotec
Cargo handling

Dedicated cargo terminals for fast cargo handling

Extended hull sides to eliminate the need for extra lashing

Source: Green Door Logistics
Safety in shipping

Air Traffic Control

Fatalities/year moving average (bold)

Passengers carried exp. fit (bold)


Radar  BCAS  TCAS

Passenger carried [Millions]
ReVolt and autonomy
Emission reduction potential

CO₂ emission reduction potential

MT CO₂/year

0 100.000 200.000 300.000 400.000 500.000 600.000

Ship level Fleet level Transport level

4 100 444 000 510 000
Lifetime Cost

OPEX ReVolt vs Base Vessel

Replacement of battery pack
Model demonstrator
ReVolt – a new solution to a safe and sustainable future for shipping
Thank you!

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