MOSES project-Technical implementation

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MOSES Facts

AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

Significantly enhance the SSS component of the European container supply chain by stimulating sustainable feeder services to ports with limited or no infrastructure!
MOSES scope within the supply chain

- Autonomous ships in port terminals and SSS feeder services
- Automated cargo handling
- Policy recommendations for SSS

SEAMLESS
1. MOSES AutoDock (MOSES Autonomous tugboats + AutoMoor)
2. MOSES Recharging Station
3. Innovative Feeder Vessel
4. Robotic container-handling system
5. MOSES matchmaking platform
The tugboat swarm will manoeuvre and dock large containerships

- **70%** Decrease in manoeuvring time for large container ships
  - Time required to position the vessel to berth

- **20%** Decrease in docking time for large container ships
  - Time required to secure the vessel in its berthing position

The KPIs will be **partly validated** from the results of Pilot Demonstration #1 and the MOSES Sustainability Framework
MOSES Automated and Autonomous technologies

The innovative feeder will transport container cargo, with minimal environmental footprint, to small ports with no infrastructure.

The KPIs will be partly validated from the results of Pilot Demonstrations #2 and #3 and the MOSES Sustainability Framework.
Autonomous Tugboats

Architecture for autonomous operation

Shore Tugboat Control Station

Tugboat #1

Tugboat #2

Manoeuvred vessel

Automated docking system

Legend

- Tugboat
- Detection Module
- Path Planning Module
- Control Module
Autonomous Tugboats

Learning in realistic scenarios!

Scenario A (with thruster)

Scenario B (without thruster)
Autonomous Tugboats

Training AI to manoeuvre a large containership through reinforcement in a virtual world!

Start of agent training

Trained agents

Distance from docking position
Max speed of approach
Distance to manoeuvred vessel
etc...

the containership is parallel to the dock
Autonomous Tugboats

Preliminary results from training process

Baseline Scenario B (without thruster)
2 pushing tugboats
2 pulling tugboats (bow, stern)

Given the constraints and reward function parameters, the “agents” have learned to manoeuvre the large vessel in a similar way as in a real tugboat operation!
Autonomous Tugboats

Autonomous manoeuvring and docking – Demonstration

Faaborg Harbor-Denmark

Boat No. 1

Boat No. 2

Manoeuvred Barge

AutoMoor Unit

Candidate locations at Faaborg port
Innovative Feeder Vessel

Concept designs based on the MOSES use cases

**Spanish concept**
- 670 TEU
- 5kn service speed
- 85 nm range

**Greek concept I, II**
- 180 TEU
- 10 kn service speed
- 266 nm range

**Innovations:**
- Sustainable propulsion (Hybrid methanol ICE + batteries, Full electric)
- Azimuth thrusters for enhanced manoeuvrability
- Automated cargo-handling, as first step towards higher autonomy
Innovative Feeder Vessel

Design process and hazard analysis

System requirements
- Concept of operations
- User needs
- Container demand

Preliminary design
- Hull form and general arrangement
- Powering configuration
- Operational cost
- Trip and potential flow simulation (MARIN)
- Power plant simulation (DNV COSMOSS)

Preliminary Hazard Analysis
- Identification of hazardous scenarios
- Risk ranking
- Requirements for detailed design

First step of Risk-Based Design

Typically used in the early stages of system design (Rausand 2011) for “establishing the initial system safety requirements (SSRs) for design from preliminary and limited design information” (Ericson 2005).

1. **Brainstorming expert sessions** → Hazards, hazardous events, worst case consequences, risk reducing measures

2. **Separate expert assessments for each hazardous event** → Frequency and consequence severity indices (FI, SI)

3. **Average of assessments** → Calculation of risk index (RI) for each hazardous event

4. Documentation in worksheet
Innovative Feeder Vessel

Preliminary Hazard Analysis results

9 High risk events / system component

Cargo space:
• Onboard crane impedes port cranes
• Water accumulation in cargo hold

Accommodation:
• Mustering process takes too long
• Limited visual monitoring of the cargo space

Engine/Propulsion machinery:
• Hybrid configuration operation & maintenance
• Generator fails due to load variations in extreme weather
• Design speed too specific

Fuel/Energy storage:
• Methanol leakage
• Batteries overheating

* Hazards apply for all three concept designs
**Innovative Feeder Vessel**

**Preliminary Hazard Analysis results**

3 Highest risk events / system component

**Cargo space:**
Onboard crane impedes port cranes →
Slower cargo handling →

\[
RI_{Supp.Chain} = 7
\]

**Accommodation:**
Limited visual monitoring of the cargo space →
Fire, cargo shift/loss not detected →

\[
RI_{Safety} = 7
\]

* Hazards apply for all three concept designs

**Cargo space:**
Water accumulates in cargo hold (open top design) →
Stability degradation, damage to cargo →

\[
RI_{Safety} = RI_{Property} = RI_{Supp.Chain} = 8
\]
Innovative Feeder Vessel

Autonomous round-trip simulation – scenario and models

The objective is to demonstrate a fully autonomous round-trip by combining different vessel control models!

- Different models are used for
  - way-point/track following,
  - Dynamic Positioning (DP) while manoeuvring,
  - docking
- A state machine is used for changing between mission phases
Innovative Feeder Vessel

Autonomous round-trip simulation – preliminary results

The simulation showcases fully automated vessel control from the port of Mykonos to the container terminal in Piraeus!
Innovative Feeder Vessel

Autonomous round-trip – Demonstration

Dock-to-dock, fully autonomous operation of the MOSES feeder

Netherlands

A scaled ship model of the Greek feeder concept will be tested in MARIN’s Seakeeping and Manoeuvring Basin (SMB)
How to support remote operators in their supervision of dozens of autonomous operations in the maritime industry.
Robotic Container-Handling System

The information from the sensor suite is used to create a 3D world model for enhancing the situation awareness of the remote operator through the IOSS system!

2D / 3D detection and pose estimation of containers

2D / 3D detection of red alerts during crane operation

2D / 3D image fusion for scene reconstruction
Robotic Container-Handling System

Autonomous crane – Demonstration

(Semi)autonomous operation of the Robotic Container-Handling System

Sweden, Netherlands

MacGregor’s crane will be retrofitted with the necessary sensors and control system for autonomous operation. The operation will be monitored remotely with the IOSS.
Feedback from the industry

MOSES impact of automation to the tugboat industry questionnaire

Benefits of automation and autonomy

60% say “increased efficiency”

Challenges of automation and autonomy

70% say “There are concerns over security”

Trust and feeling safe onboard a fully autonomous tugboat

90% would moderately trust the system or not at all

What should the MOSES project consider during development?

“Innovation and new technologies can lead to limited human presence, but it is impossible to completely eliminate the crew of a harbour tug”

“Crew safety, environment and property protection”

How would you make the autonomous operation of the “tugboat swarm” more efficient in realistic conditions?

“There should be a crew of at least two people onboard”

“More emphasis should be placed on safety and emergency cases”
Thank you very much for your attention!

If you have any questions or require further information, please contact us:

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