# MOSES project-
# Technical implementation

Associate Prof. Nikolaos P. Ventikos, NTUA

European Maritime Safety Agency

**Workshop on Maritime Autonomous Surface Ships (MASS)**

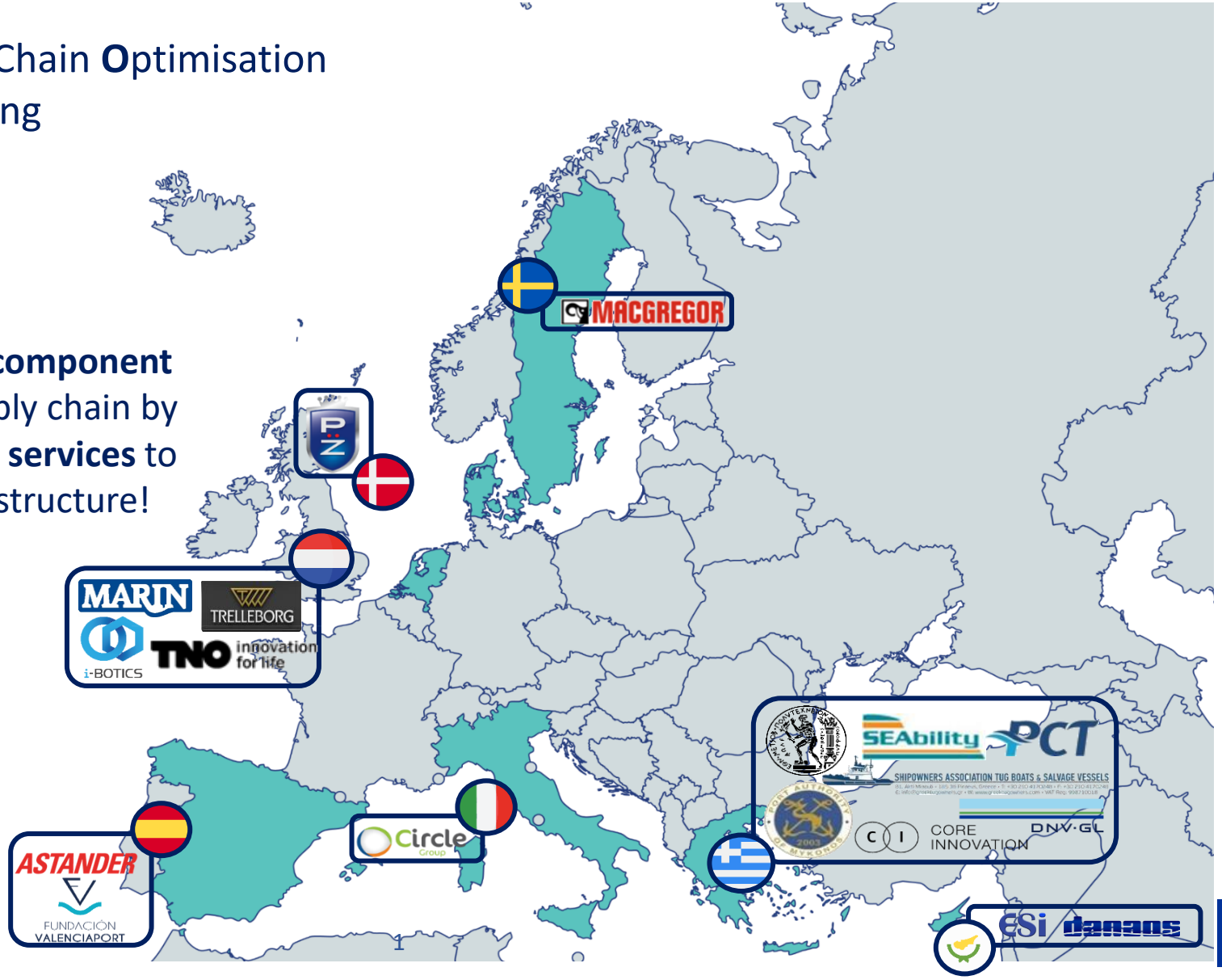
This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement No. 861678.

29.11.2022

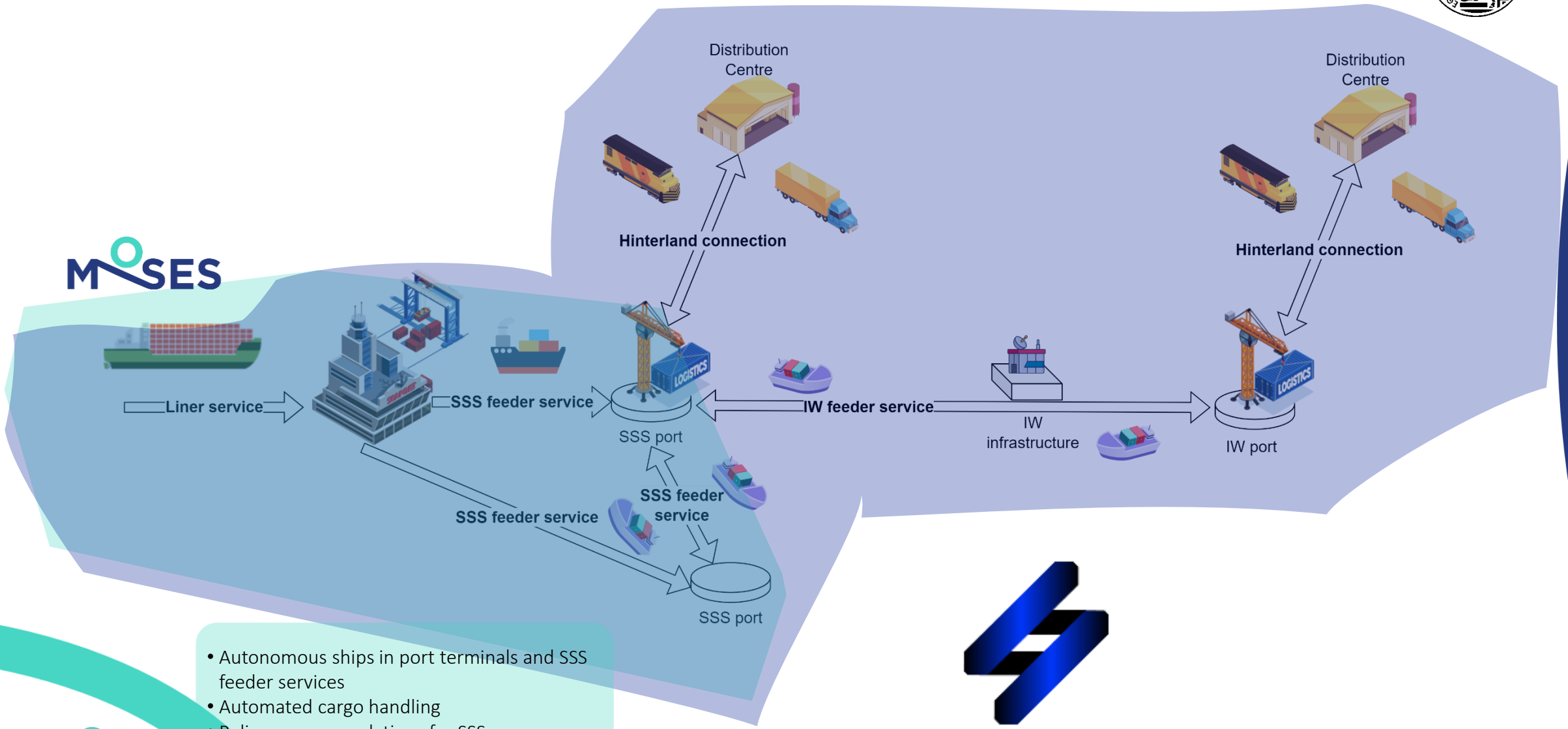
# MOSES Facts

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!



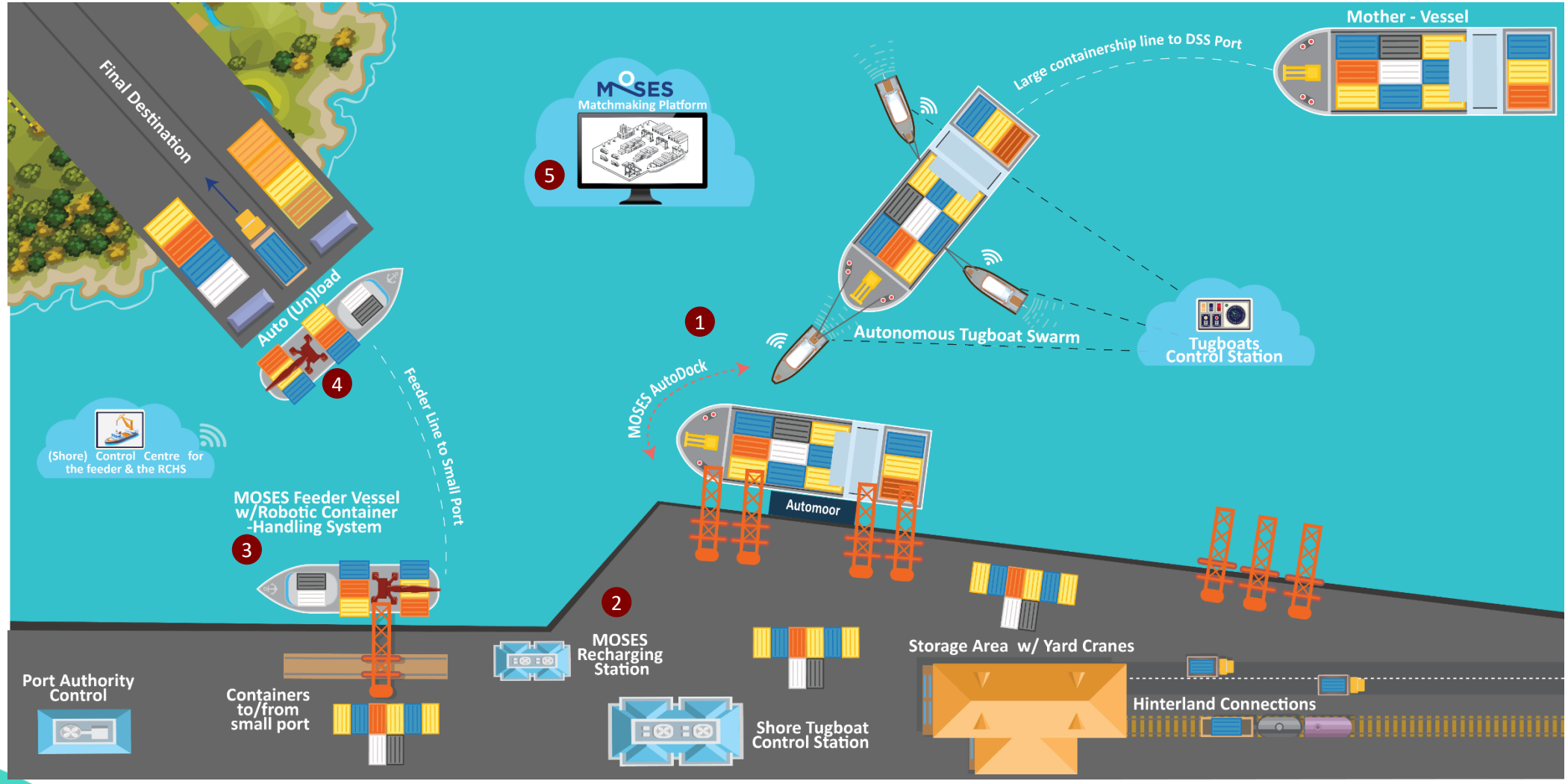
# MOSES scope within the supply chain




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

SEAMLESS

# MOSES Automated and Autonomous technologies




1. MOSES AutoDock (MOSES Autonomous tugboats + AutoMoor)
2. MOSES Recharging Station
3. Innovative Feeder Vessel
4. Robotic container-handling system
5. MOSES matchmaking platform

# MOSES Automated and Autonomous technologies

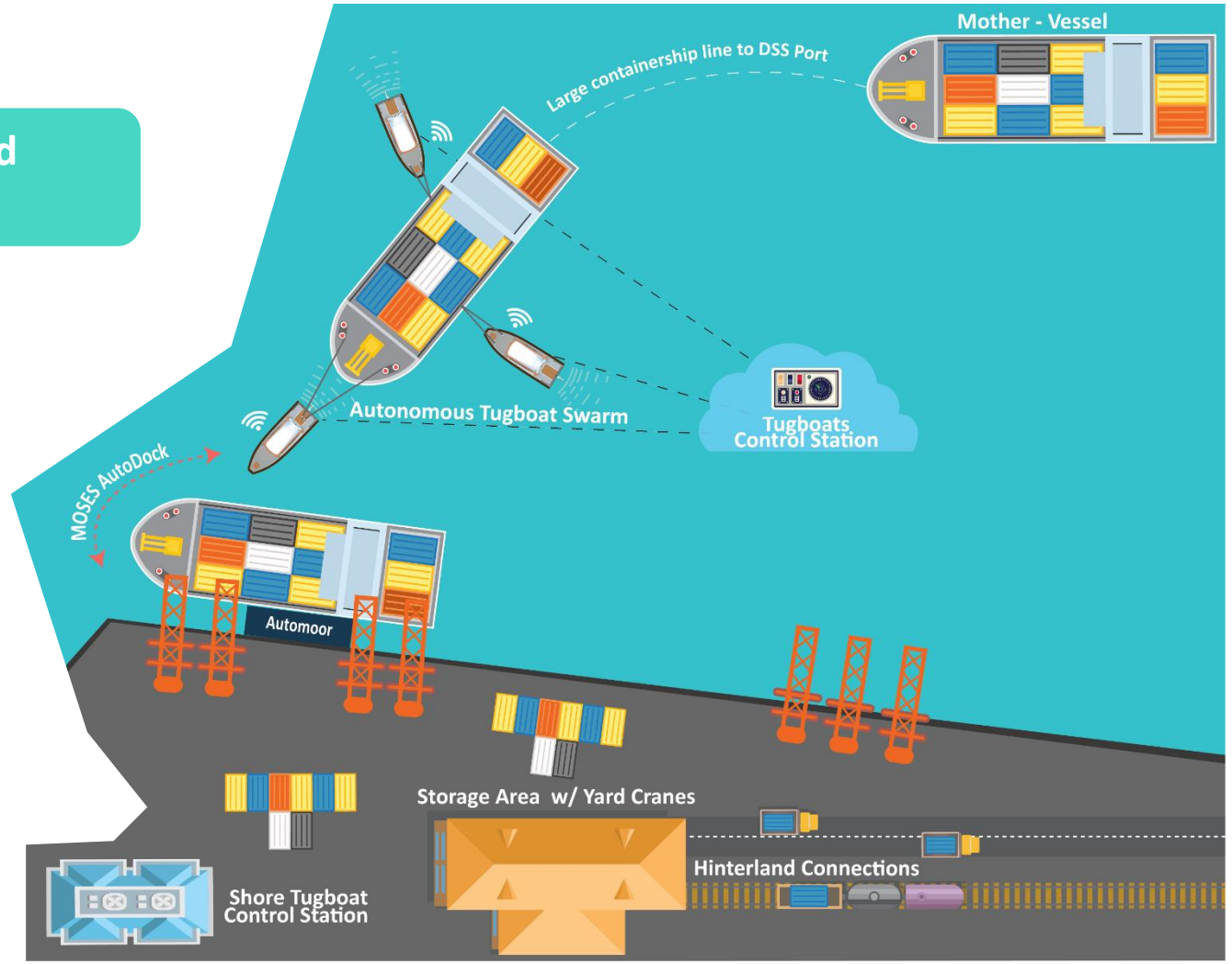
**The tugboat swarm will manoeuvre and dock large containerships**


**Decrease in manoeuvring time for large container ships**

*Time required to position the vessel to berth*

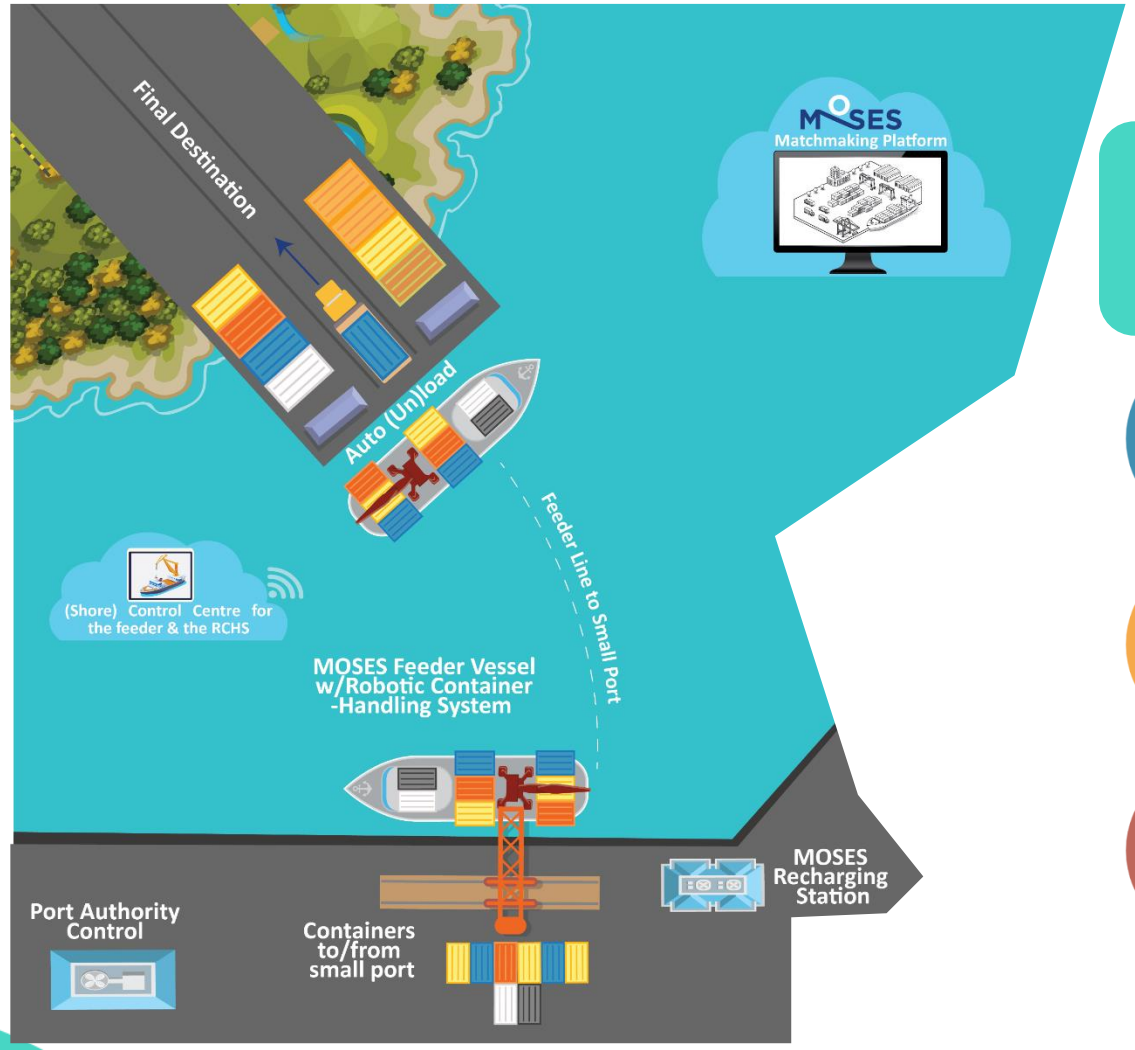

**Decrease in docking time for large container ships**

*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

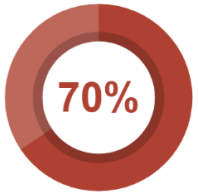



**The innovative feeder will transport container cargo, with minimal environmental footprint, to small ports with no infrastructure**


**Decrease of loading time for feeder vessel**


**Decrease of large crane usage in DSS port for (un)loading feeder vessel**

*KPI: % of usage time allocated to (un)loading feeder vessels at DSS ports*

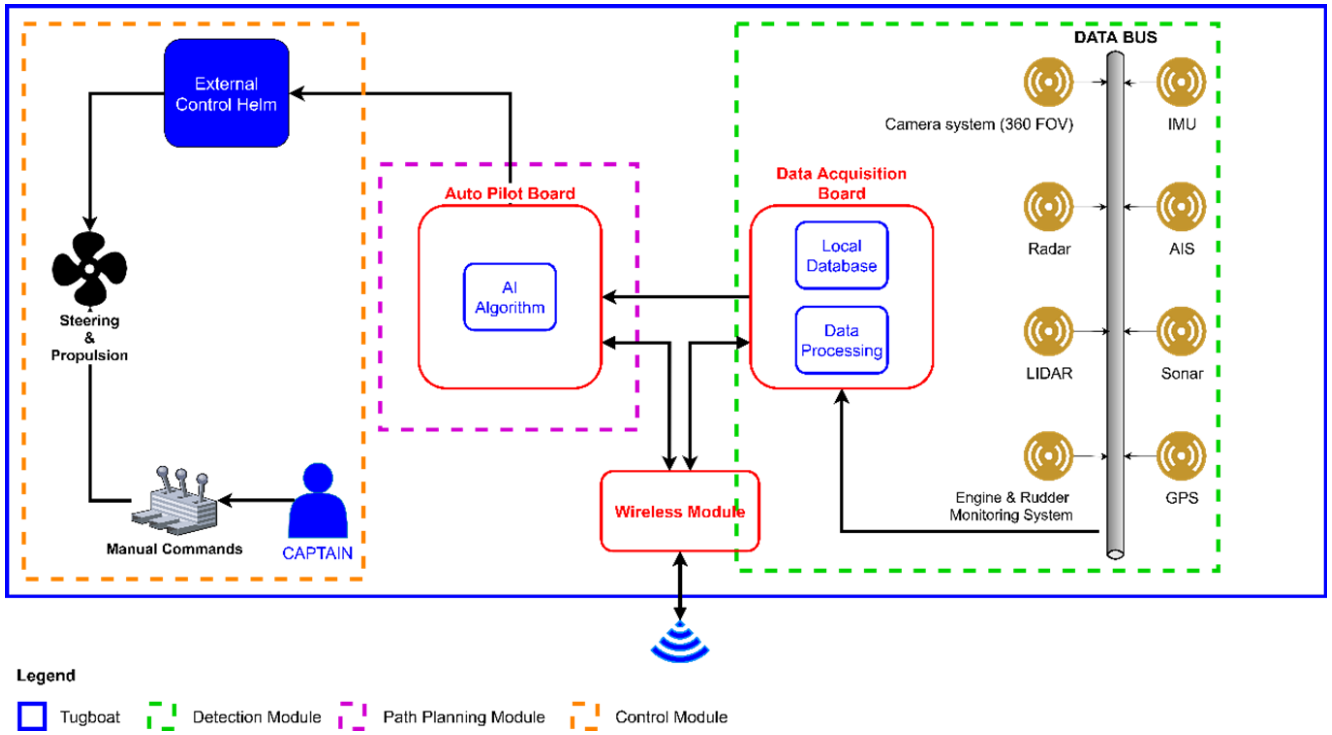


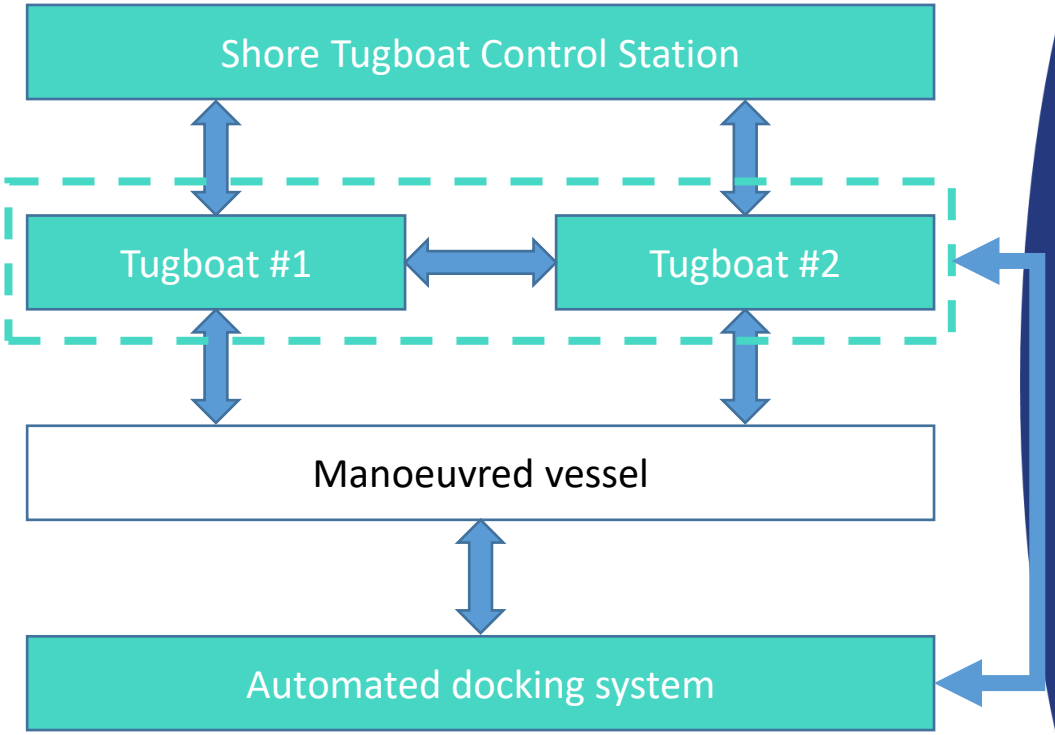

**Decrease in docking time for feeder, when combined with MOSES Automated Docking**

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



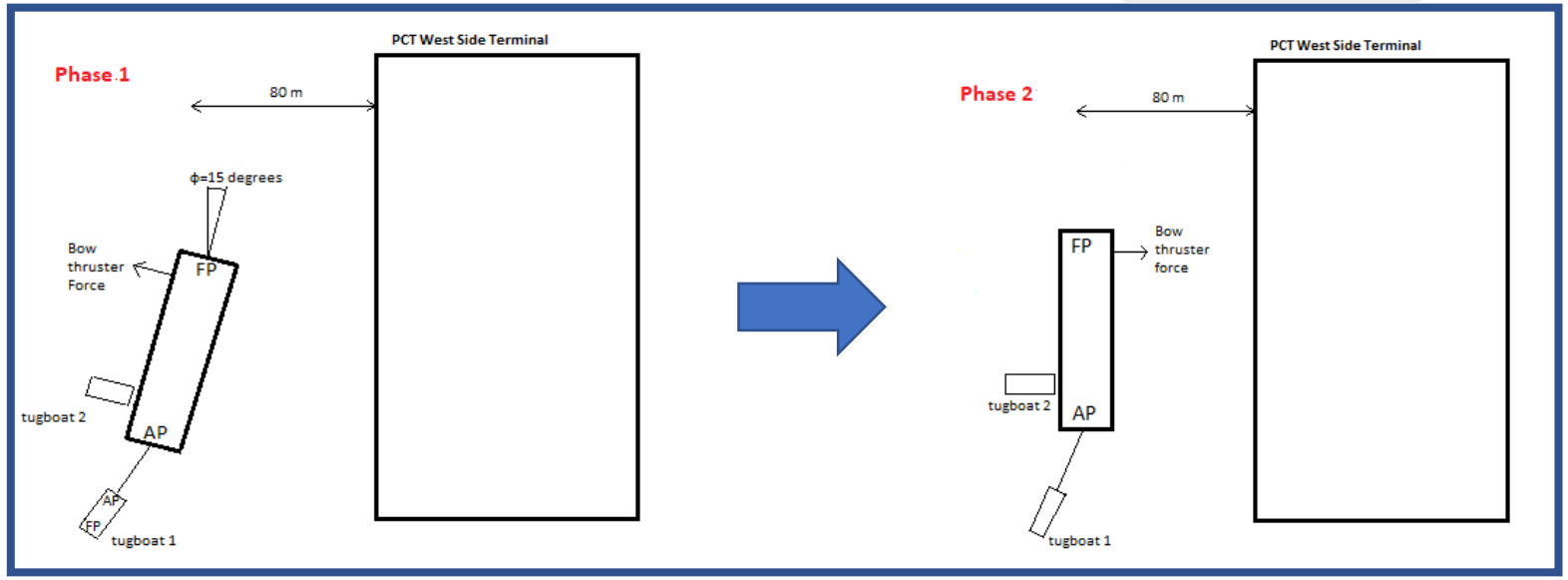



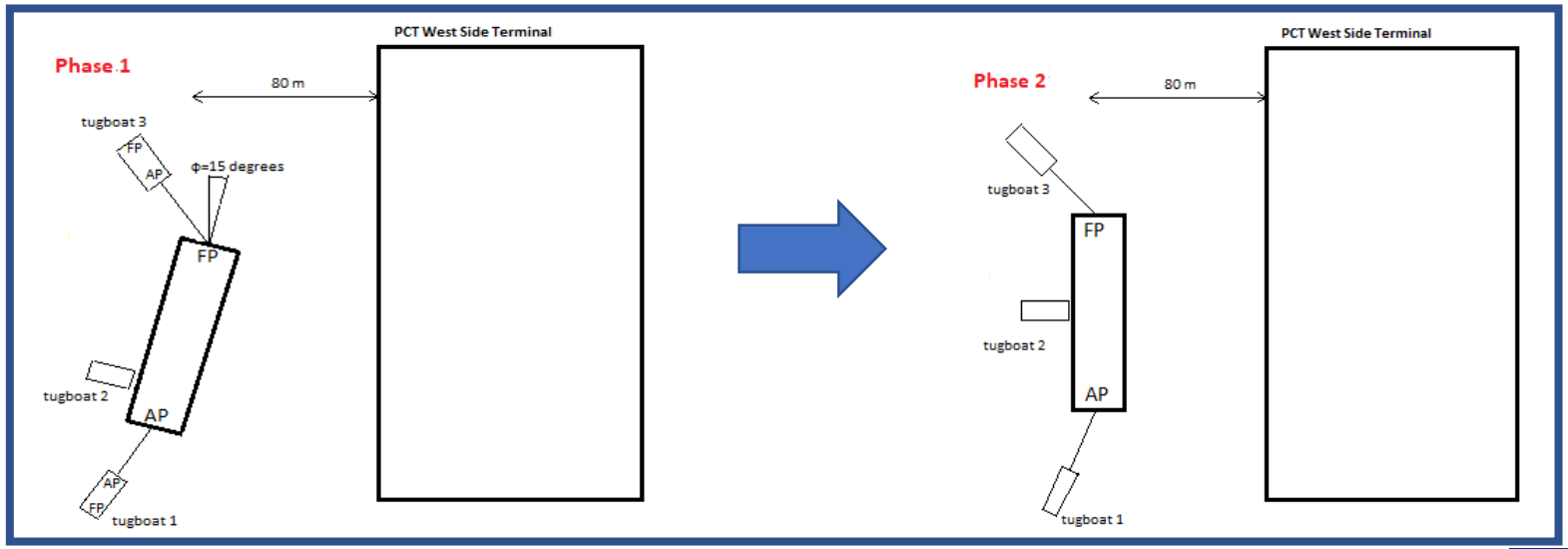

# Autonomous Tugboats

**Learning in realistic scenarios!**

**Scenario A (with thruster)**


**Scenario B (without thruster)**



# Autonomous Tugboats

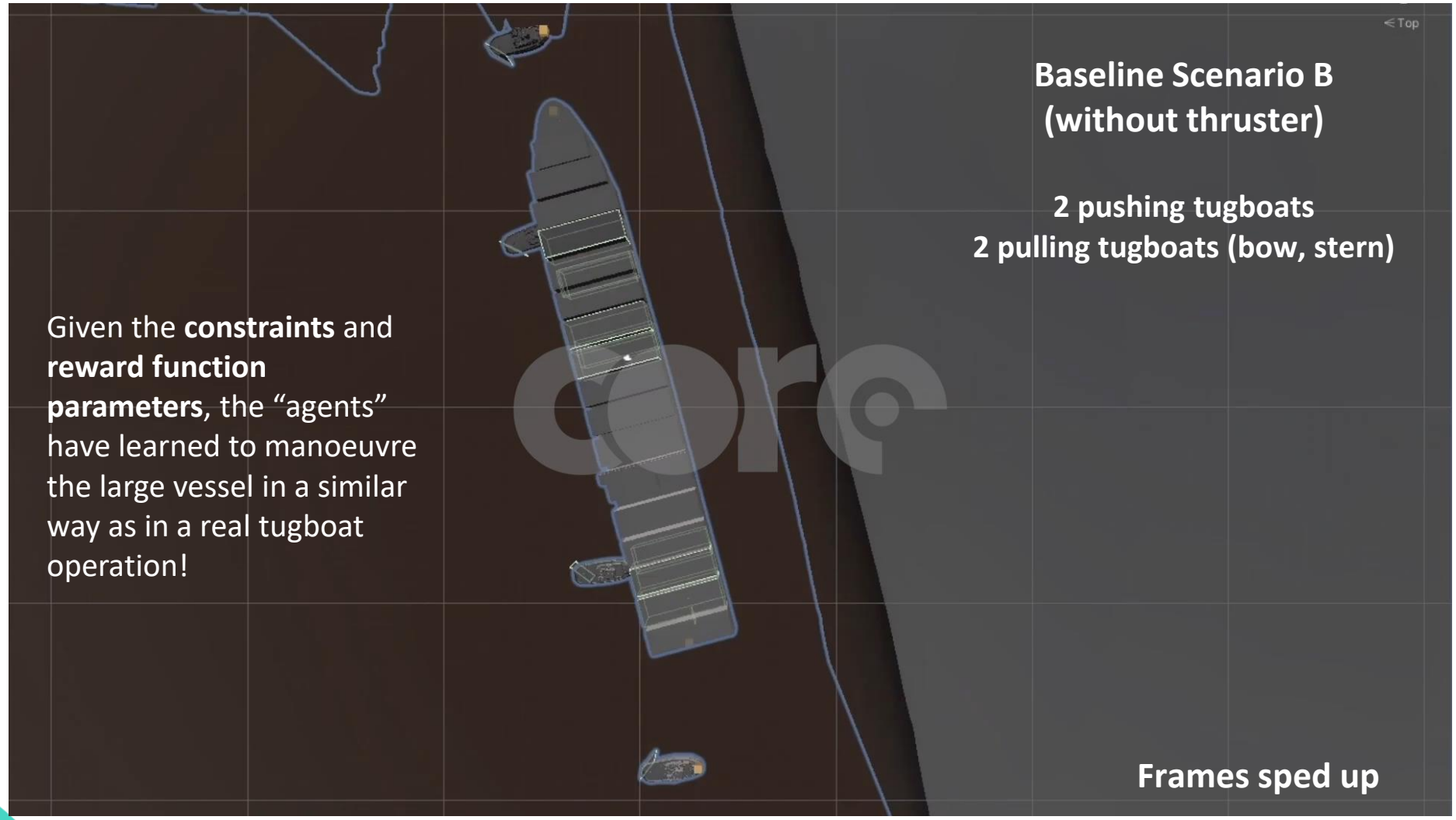
**Training AI to manoeuvre a large containership through reinforcement in a virtual world!**

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



# Autonomous Tugboats

## Preliminary results from training process

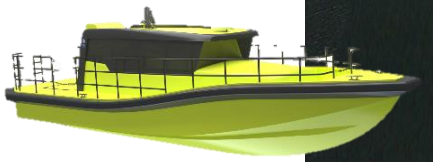



Given the **constraints** and **reward function parameters**, the “agents” have learned to manoeuvre the large vessel in a similar way as in a real tugboat operation!

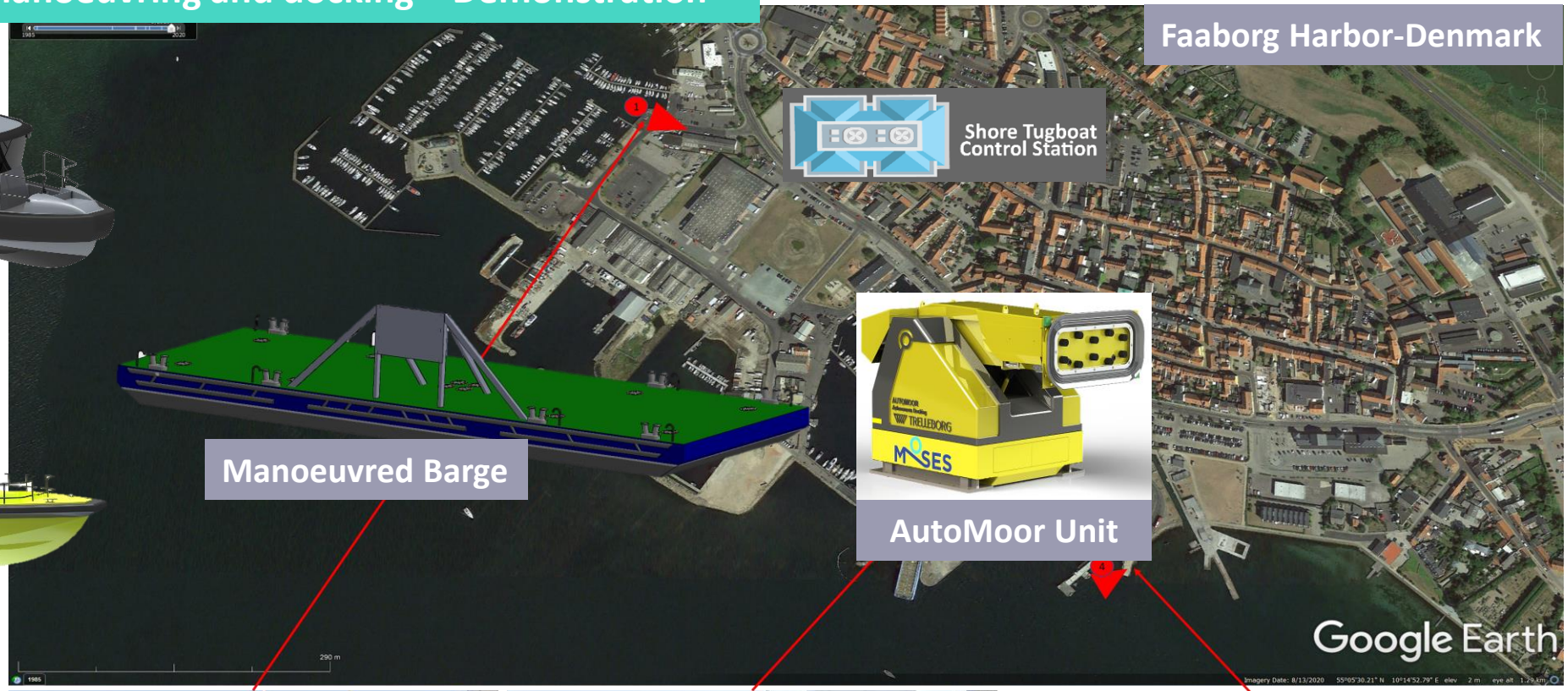
# Autonomous Tugboats

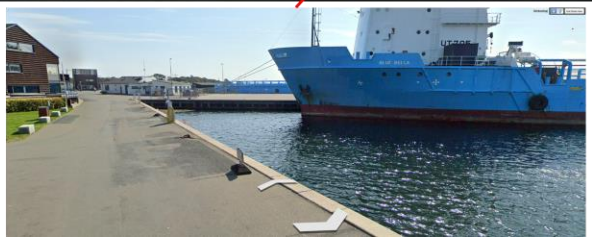
## Autonomous manoeuvring and docking – Demonstration

Boat No. 1



Boat No. 2



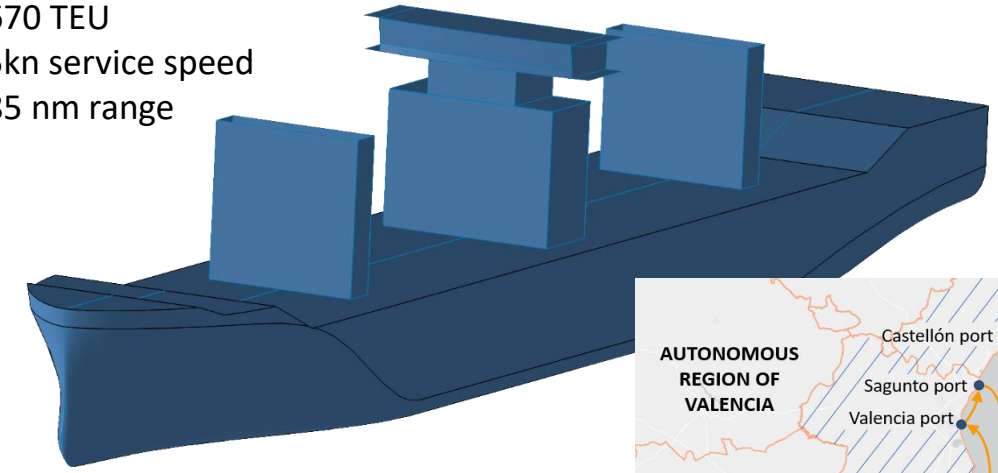
Candidate locations at Faaborg port

# Innovative Feeder Vessel

## Concept designs based on the MOSES use cases

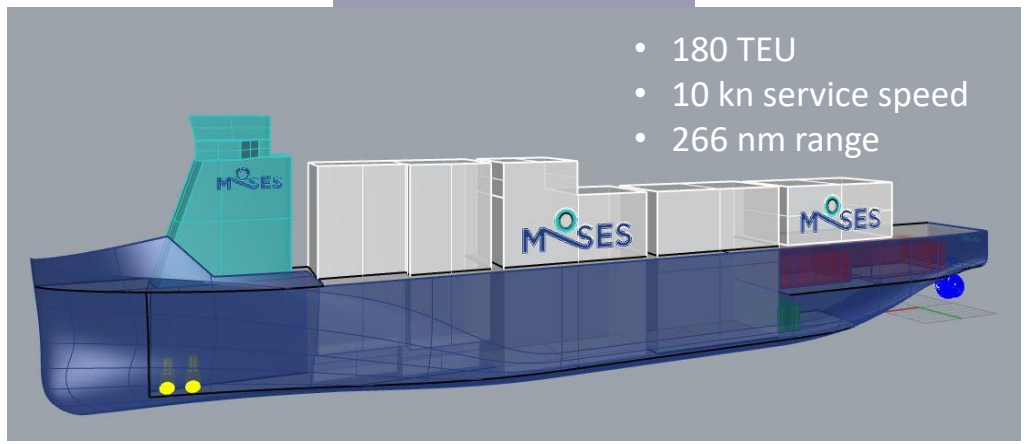
### Spanish concept

- 670 TEU
- 5kn service speed
- 85 nm range

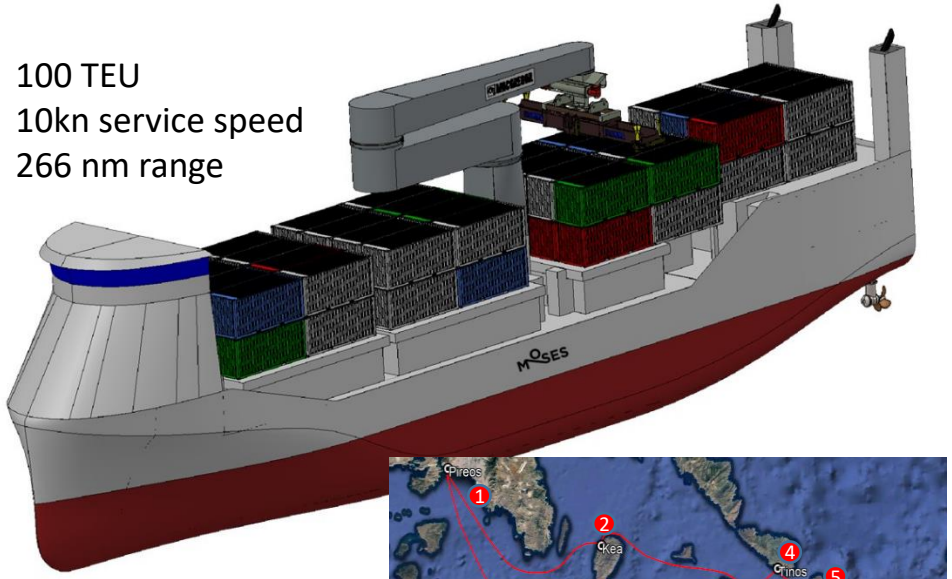


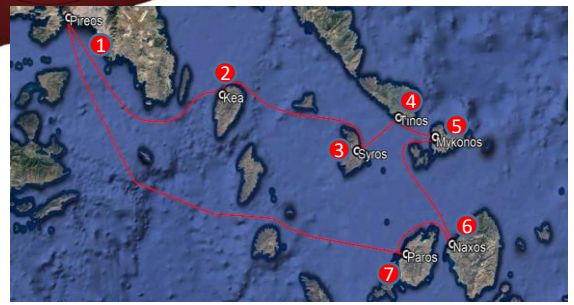

### Greek concept I, II

- 180 TEU
- 10 kn service speed
- 266 nm range



- 100 TEU
- 10kn 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 — Trip and potential flow simulation (MARIN)
- Powering configuration — Power plant simulation (DNV COSMOSS)
- Operational cost

**First step of Risk-Based Design**

**Preliminary Hazard Analysis**

- Identification of hazardous scenarios
- Risk ranking
- Requirements for detailed 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

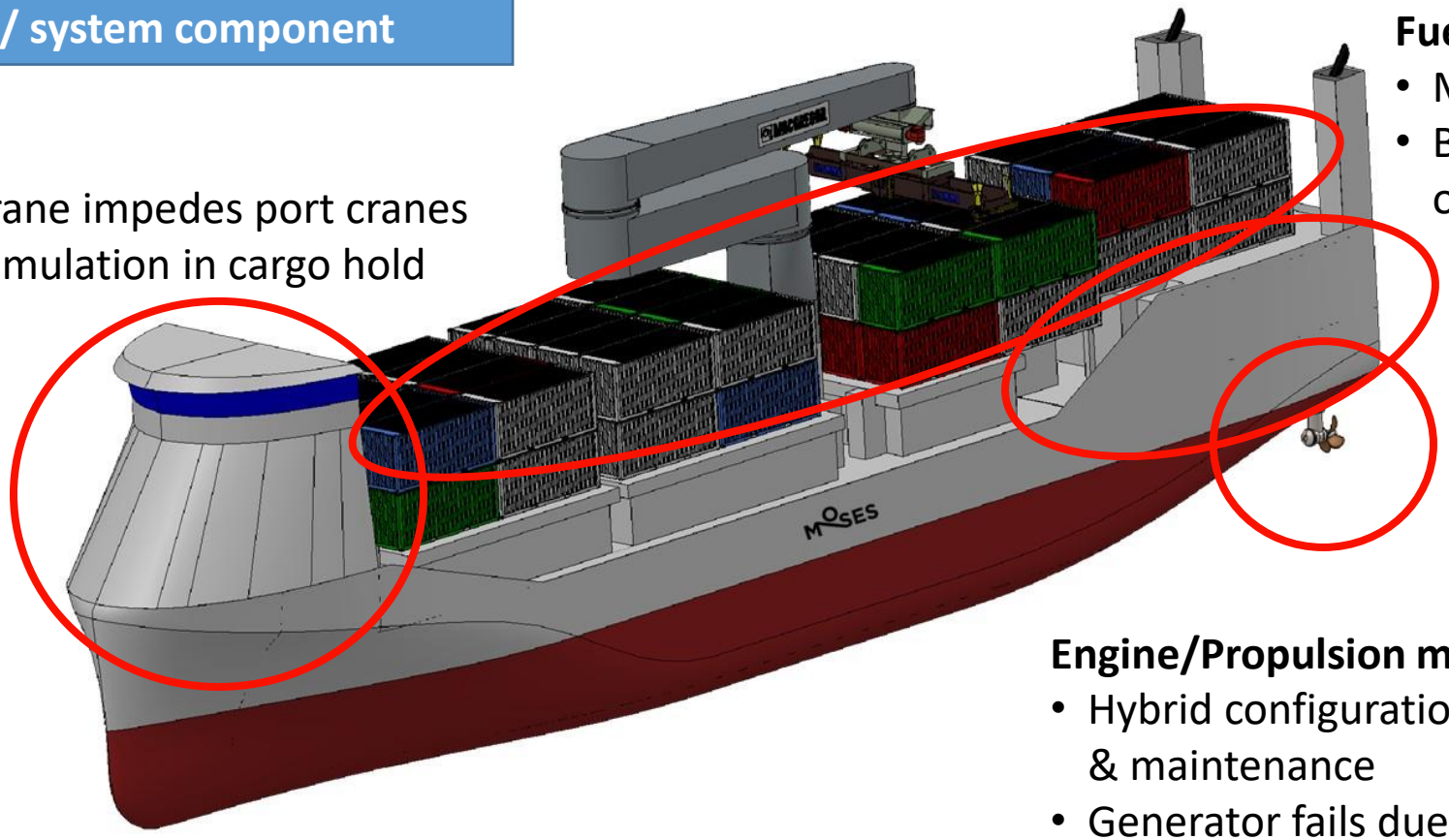
# Innovative Feeder Vessel

## 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




**Fuel/Energy storage:**
- Methanol leakage
- Batteries overheating

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

*** Hazards apply for all three concept designs**

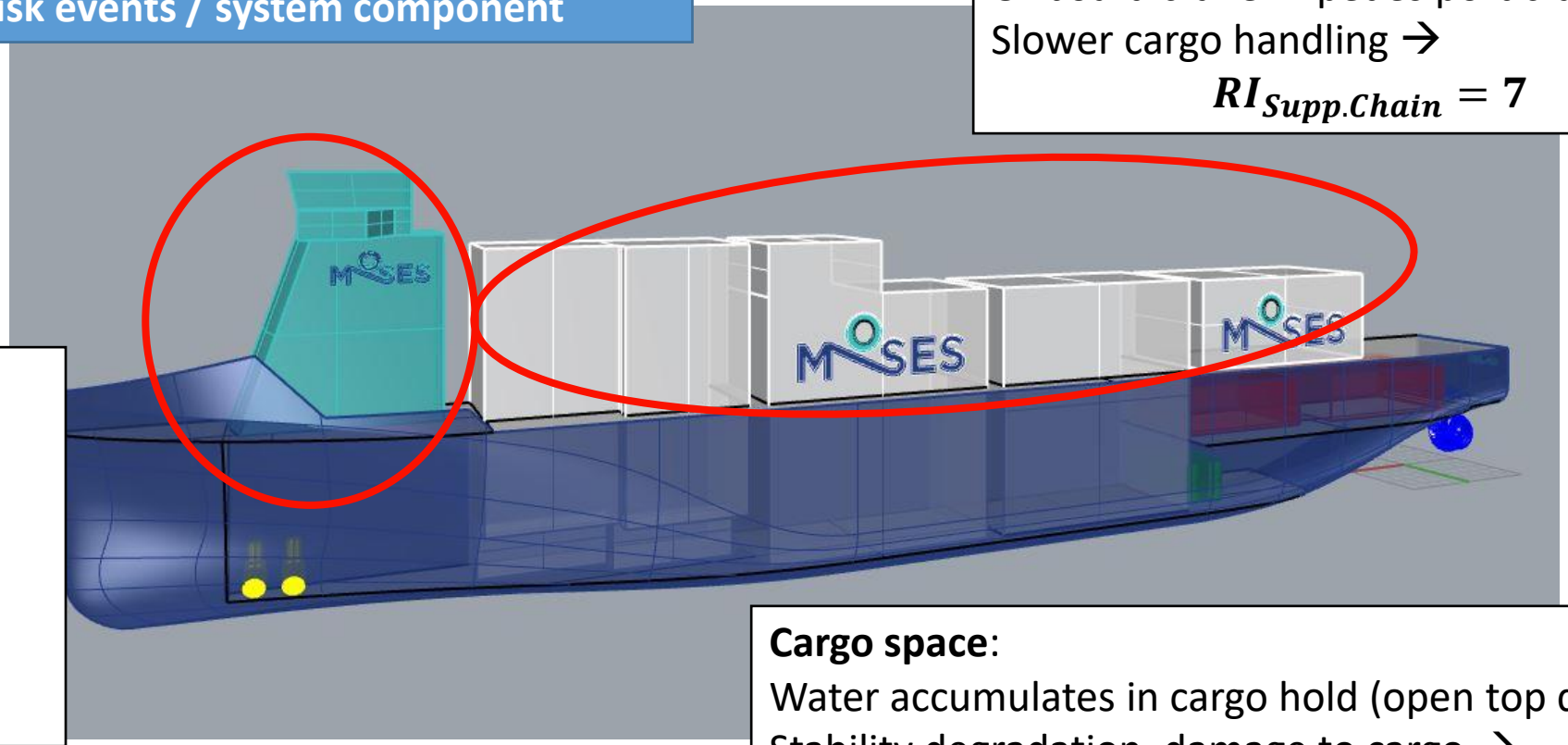
# Innovative Feeder Vessel

## 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 →

$$RI_{Safety} = 7$$

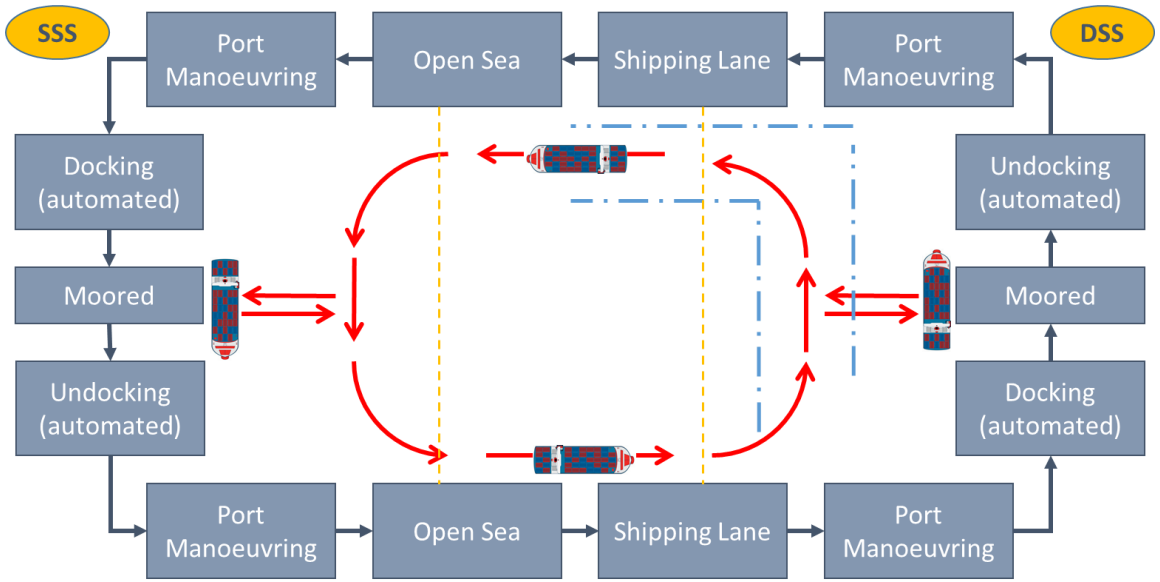
**Cargo space**:
Water accumulates in cargo hold (open top design) →
Stability degradation, damage to cargo →

$$RI_{Safety} = RI_{Property} = RI_{Supp.Chain} = 8$$

*** Hazards apply for all three concept designs**

# Innovative Feeder Vessel

## Autonomous round-trip simulation – scenario and models

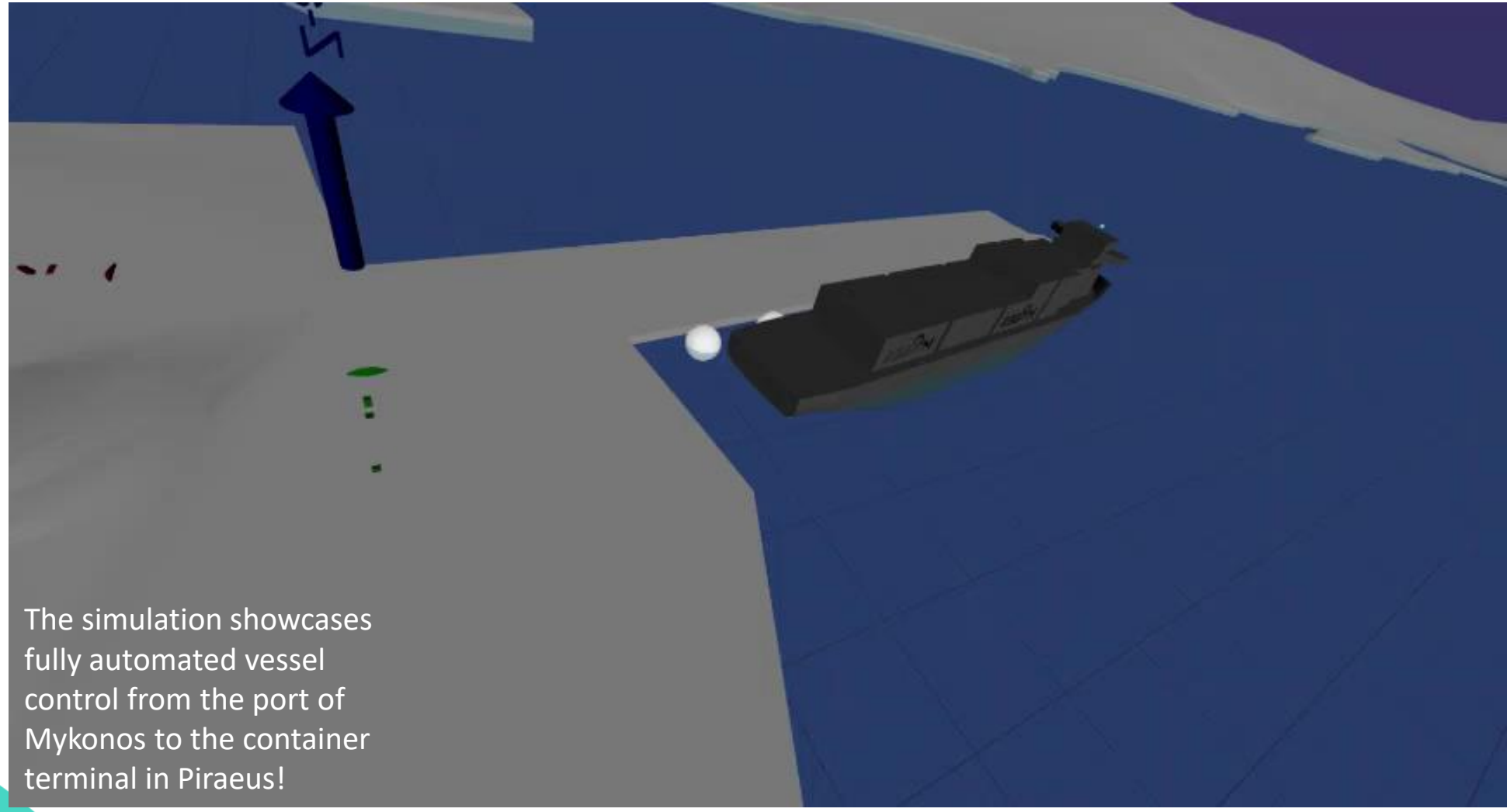



The objective is to demonstrate a fully autonomous round-trip by combining different vessel control models!

- 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

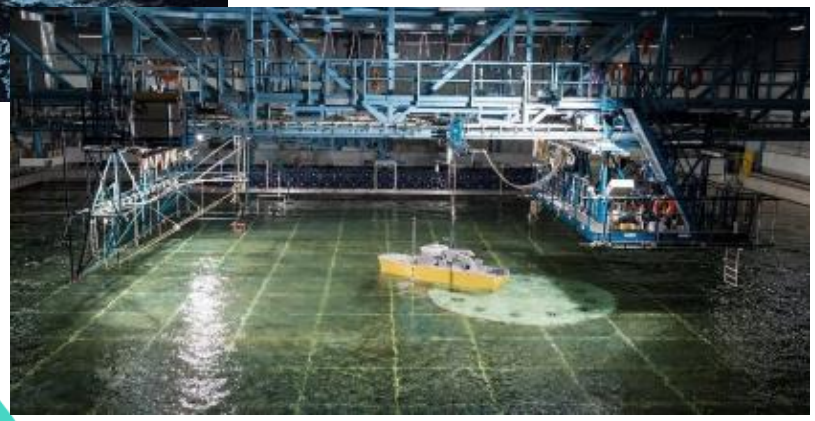


The simulation showcases fully automated vessel control from the port of Mykonos to the container terminal in Piraeus!

# 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)

# Robotic Container-Handling System

**How to support remote operators in their supervision of dozens of autonomous operations in the maritime industry.**

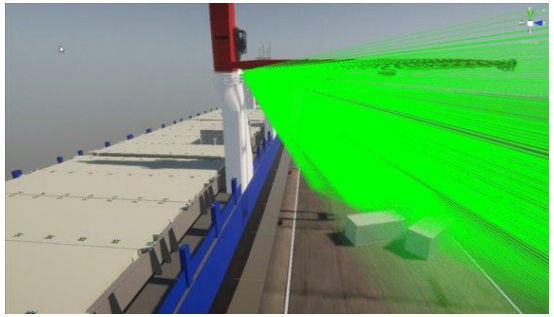
# Robotic Container-Handling System

## Sensor Suite

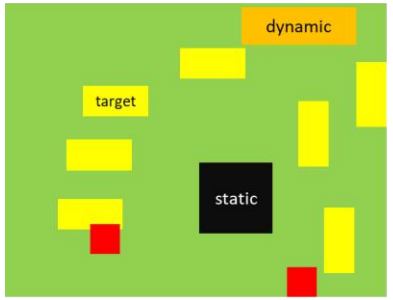
The information from the sensor suite is used to create a 3D world model for enhancing the situation awareness of the remote operator through the IOSS system!

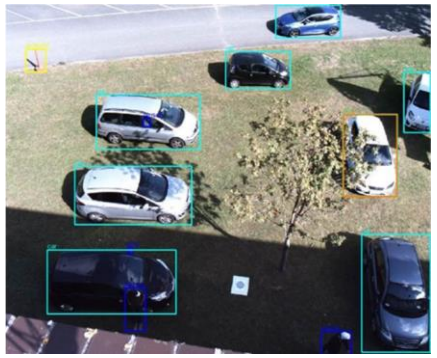
2D / 3D image fusion for scene reconstruction

2D / 3D detection and pose estimation of containers



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



# 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**"*

www. moses-h2020.eu

MOSES project2020

@mosesproject20

MOSES Project

# Thank you very much for your attention!

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

Associate Prof. Nikolaos P. Ventikos
National and Technical University of Athens-NTUA

*email*: niven@deslab.ntua.gr

This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement No. 861678.