Inland Navigation Week

The MOSES Project

Automated and autonomous technologies for modal shift to Short Sea Shipping

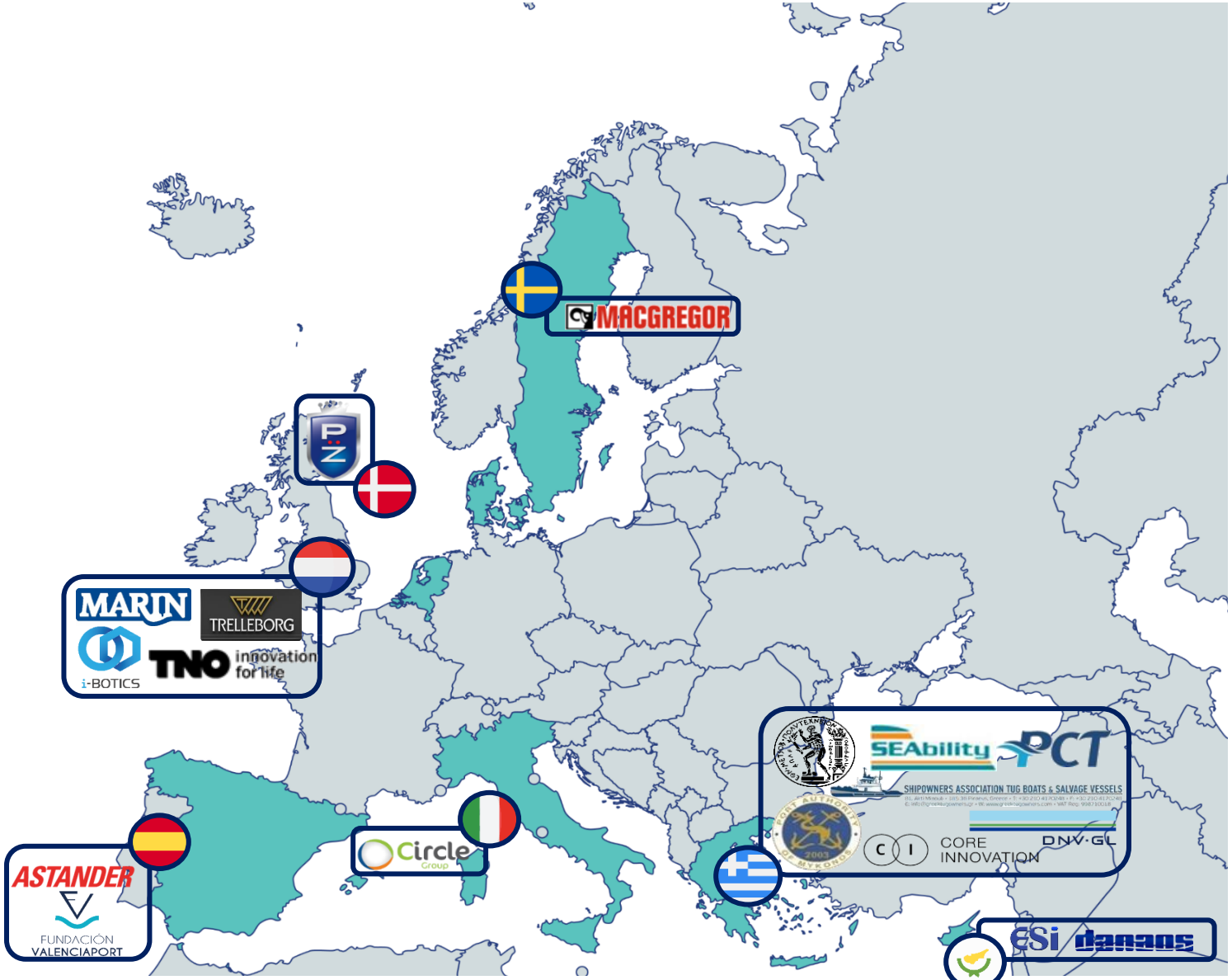
Nikolaos P. Ventikos
Associate Professor, NTUA

Konstantinos Louzis
PhD Candidate, Research Engineer, NTUA

21 March 2023

Facts about the MOSES project

- **Project Title:** AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping
- **Duration:** 01.07.2020 - 30.06.2023 (36 months) – *to be extended*
- **Budget:** 8 million €
- **Consortium:** 17 Partners



The EU container supply chain

Maritime transport is efficient and green, mainly due to economies of scale!

The EU aims at **shifting cargo** from land-based transportation to more environmentally friendly modes.

To increase the share of SSS in the container supply chain:

- Feeder routes must reach **more destination ports**.
- Feeder vessels must **carry less cargo cost effectively**.

MOSES ambition/main objective

Significantly **enhance the SSS component** of the European container supply chain!

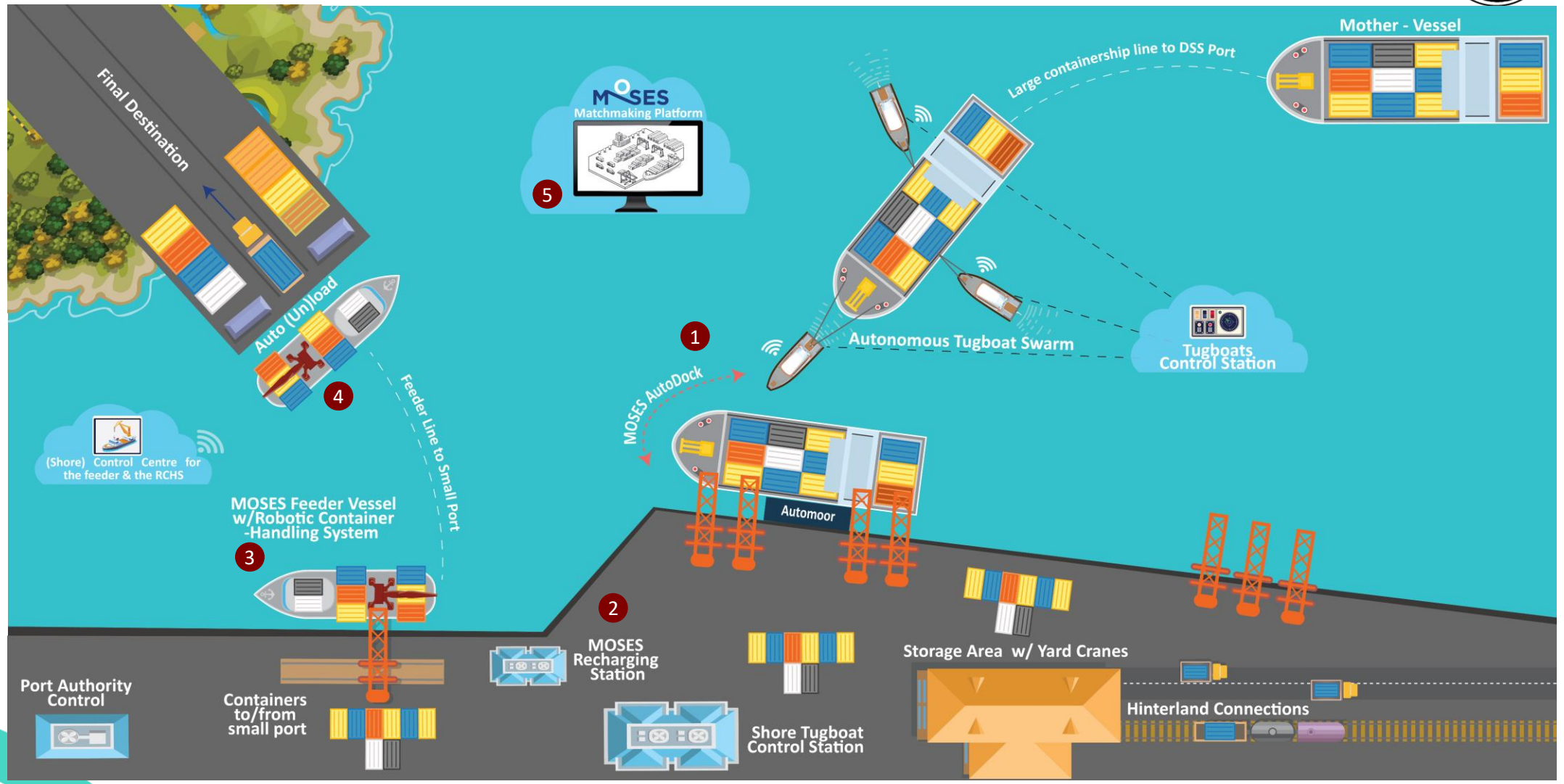
sustainable feeder services

5% Minimum decrease of end-to-end costs for container transport with feeder services

15% Increase of feeder traffic between large terminals and small ports

10% Modal shift to Short Sea Shipping in designated areas

The MOSES Concept



MOSES Innovations:

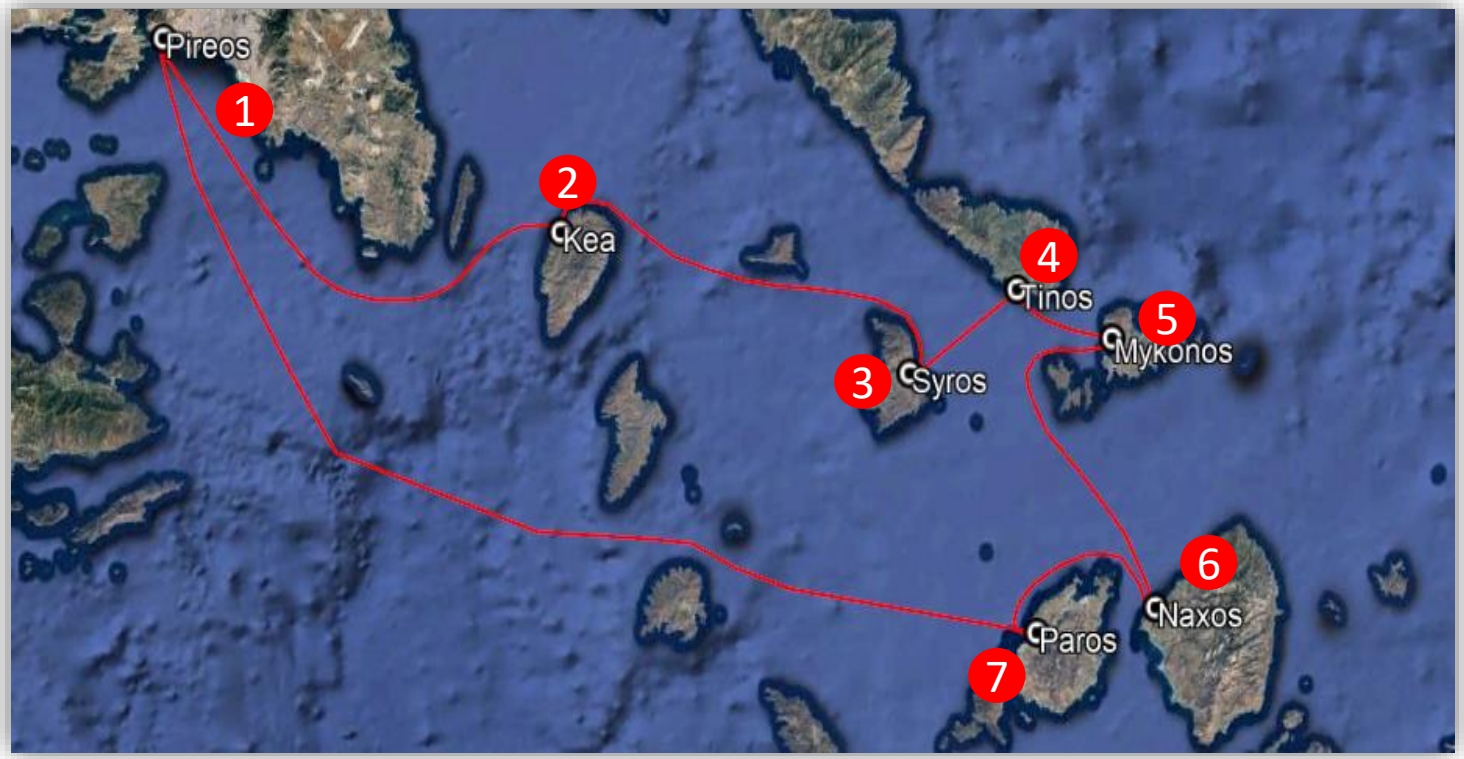
1. MOSES AutoDock (MOSES Autonomous tugboats + AutoMoor)
2. MOSES Recharging Station
3. Innovative Feeder Vessel
4. Robotic container-handling system
5. MOSES matchmaking platform

“Western MED-Spain” use case

Objective:
Decongest truck transport traffic in Valencia port and connect two Sagunto and Gandia satellite ports

- The feeder would be competitive to existing cargo transport options if **40% of the maximum estimated demand** is captured.
- Feeder service with a frequency of **three weekly services**, with geared ships.
- The expected cost-effective capacity of the vessel is **600-700 TEUs**.

“Eastern MED-Greece” use case



The 7 island ports represent **87% of the total general cargo traffic** (based on 2019 data)

Objective:
Decongest Piraeus container terminal and integrate small Greek ports into the container supply chain

- The feeder would be competitive to existing cargo transport options if **80% of the maximum estimated demand** is captured.
- At least **two weekly services** in each port.
- The expected cost-effective capacity of the vessel is **300-400 TEUs**.

Autonomous tugboats | State of the art

RECOTUG
(remote control test)

POSH Harvest
(autonomous nav. test)

Seamachines Nellie Bly
(autonomous nav. test)

Robert Allan RAMORA
(remotely controlled concept)

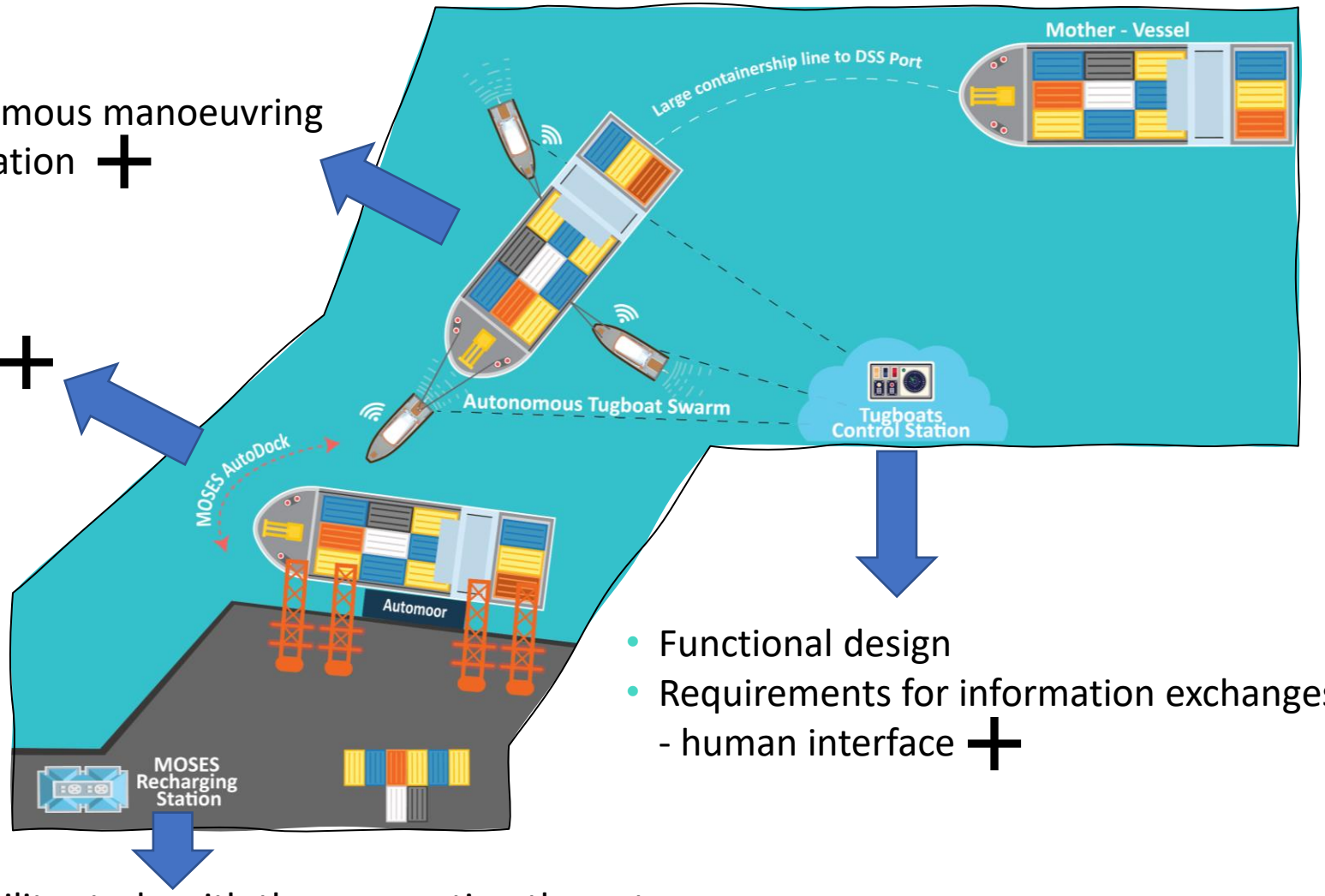
IntelliTug
(decision support,
autonomous nav. test)

Kotug
(autonomous
nav. test)

AutoDock | Design and MOSES scope

- Architecture
- Artificial Intelligence for autonomous manoeuvring
- Requirements for fail-safe operation +

Adapted AutoMoor prototype +

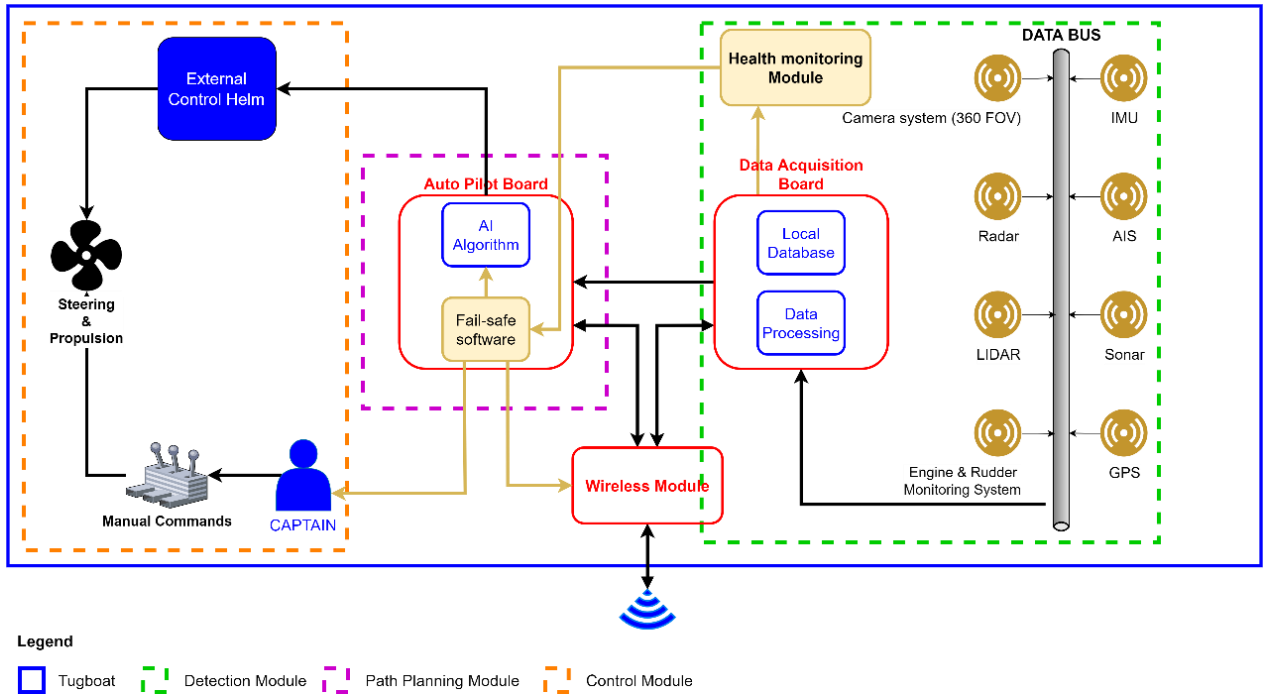


- Functional design
- Requirements for information exchanges - human interface +

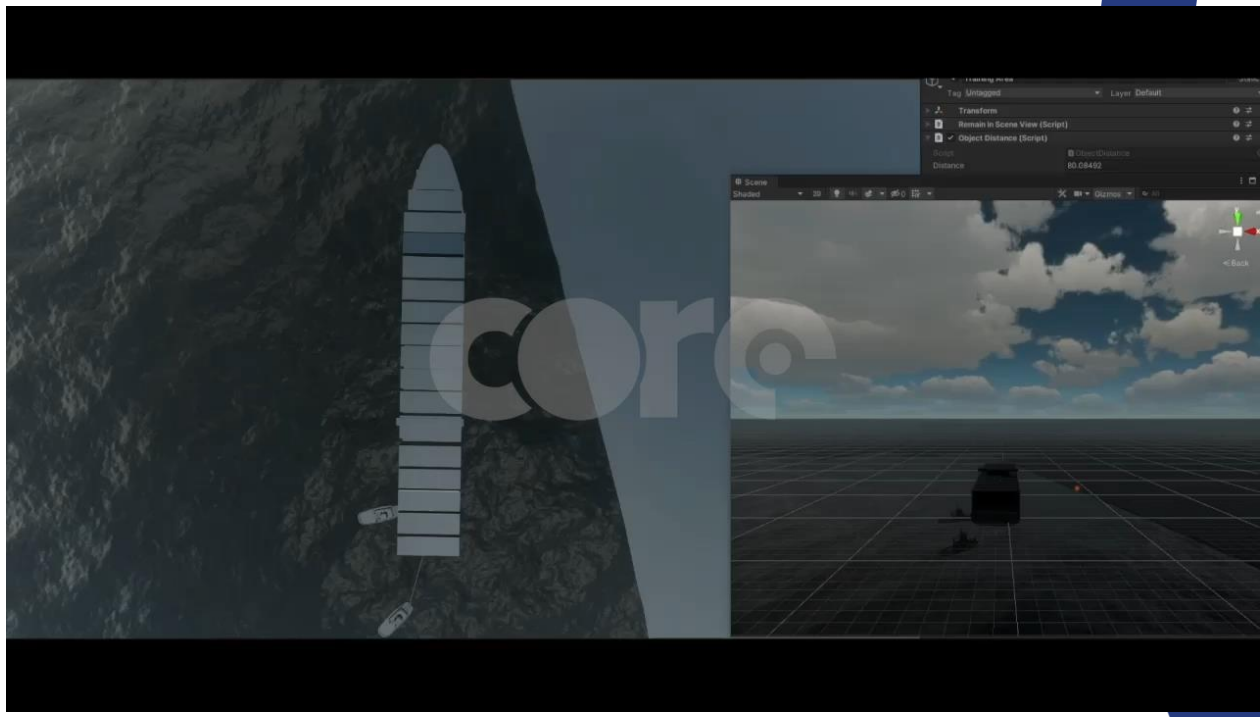
Feasibility study with the assumption the autonomous tugboats are electric (battery or hybrid)

AutoDock | Autonomous Tugboat Swarm

Architecture



Artificial Intelligence



The “agents” have learned to manoeuvre the large vessel in a similar way as in a real tugboat operation!

Fail-safe strategy

Unsafe control → Minimum Risk State

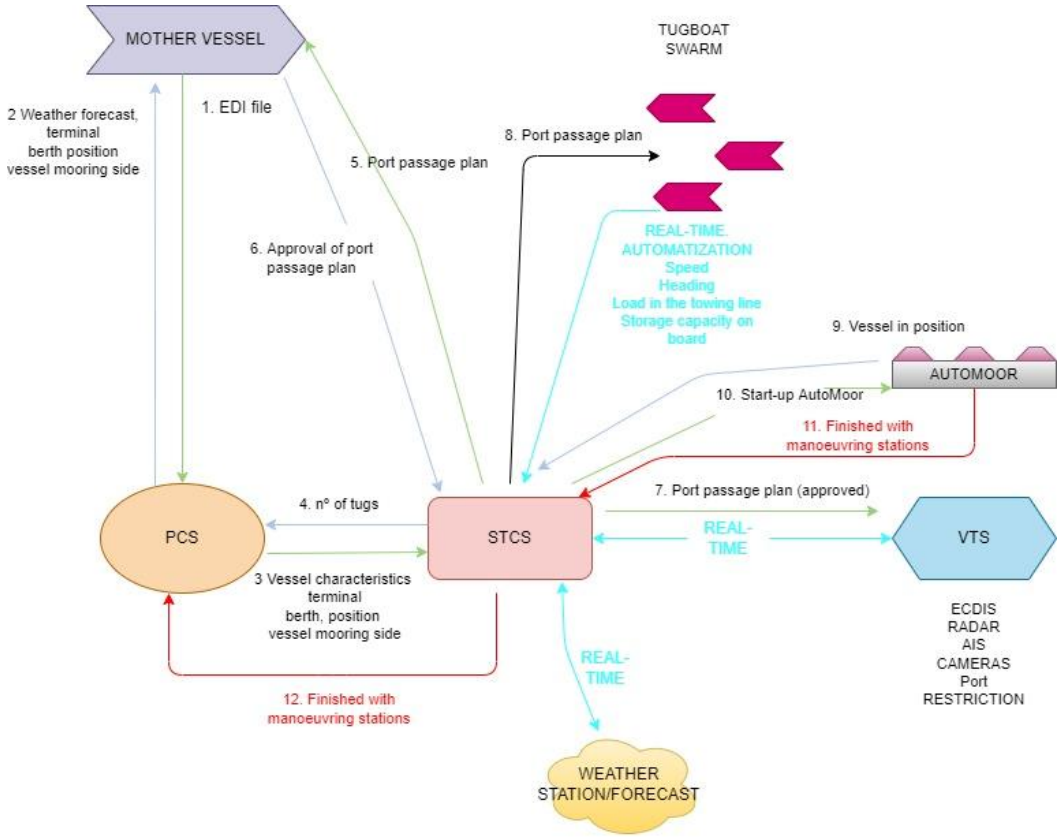
Mostly manual control

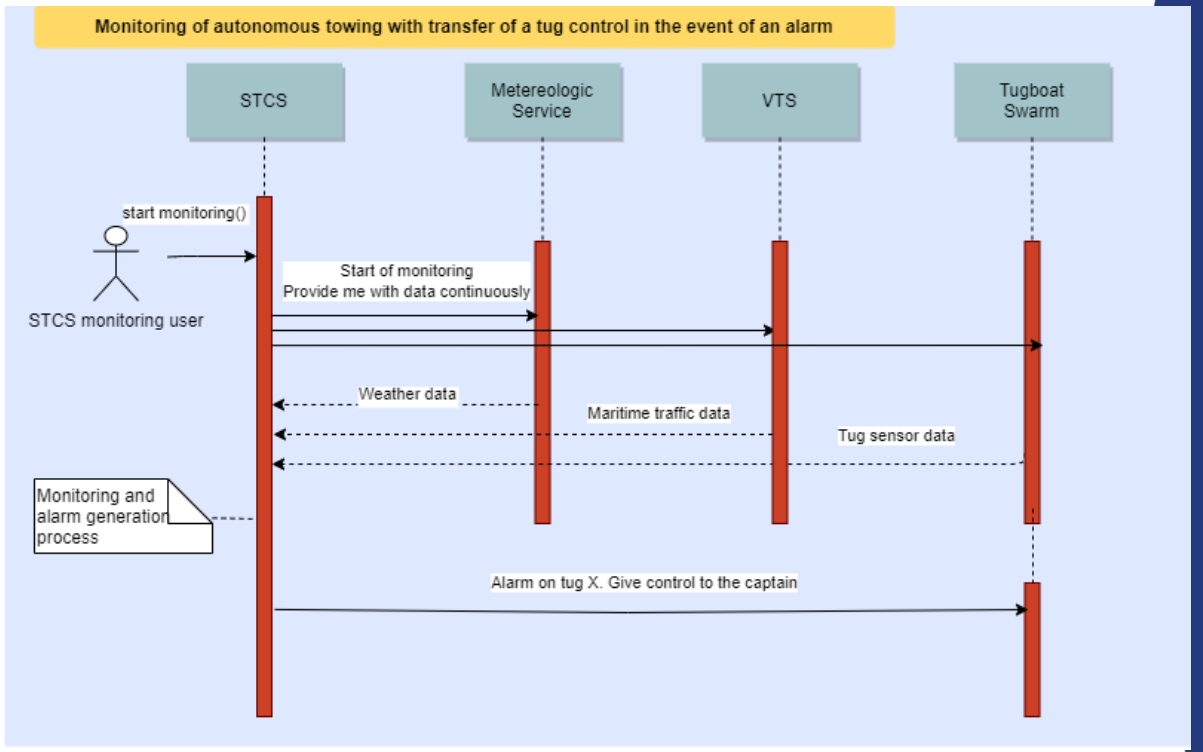
AutoDock | Automated Mooring System

Prototype innovations:

- Small-scale
- Surge motion control
- Energy harvesting
- Communication with tugboats

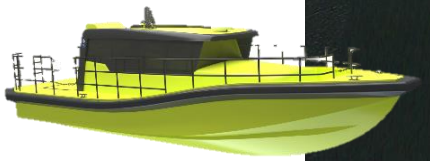
AutoDock | Shore Tugboat Control Station



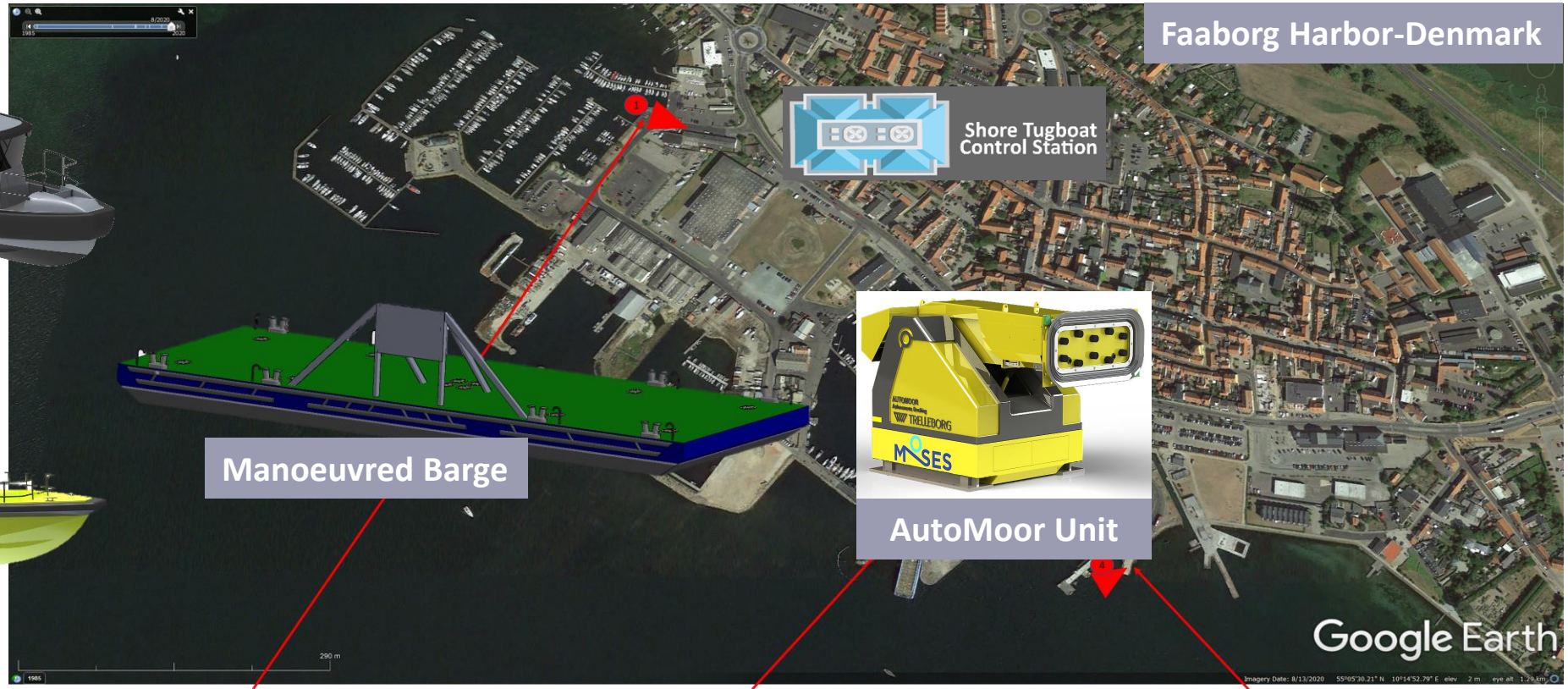


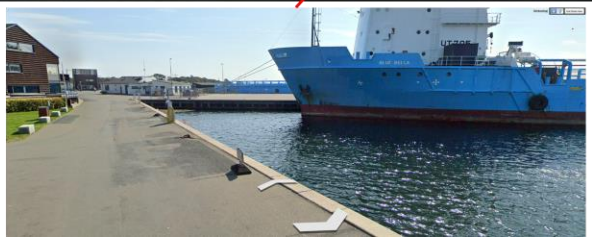
AutoDock | Pilot Demonstration

Boat No. 1



Boat No. 2



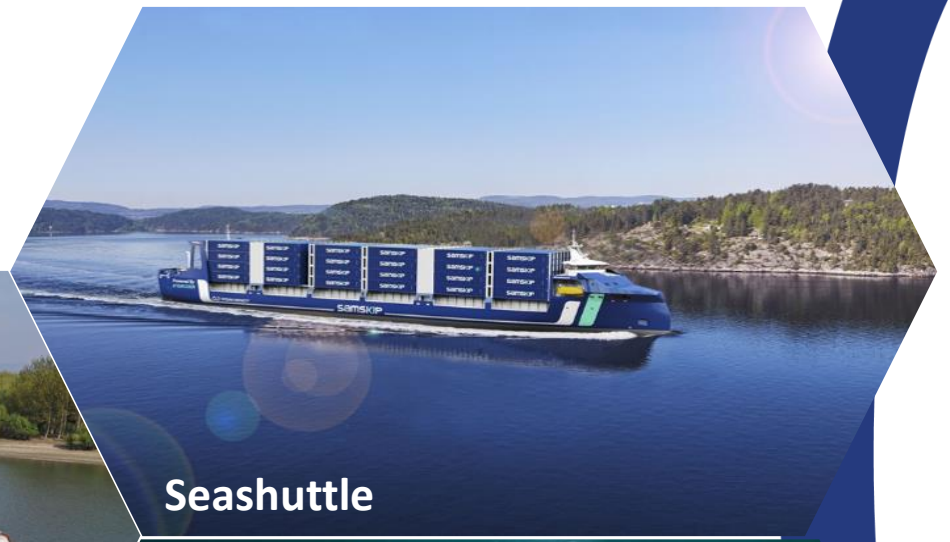


Candidate locations at Faaborg port

Innovative Feeder | State of the art

ASKO

Yara Birkeland



Seashuttle

Zhi Fei

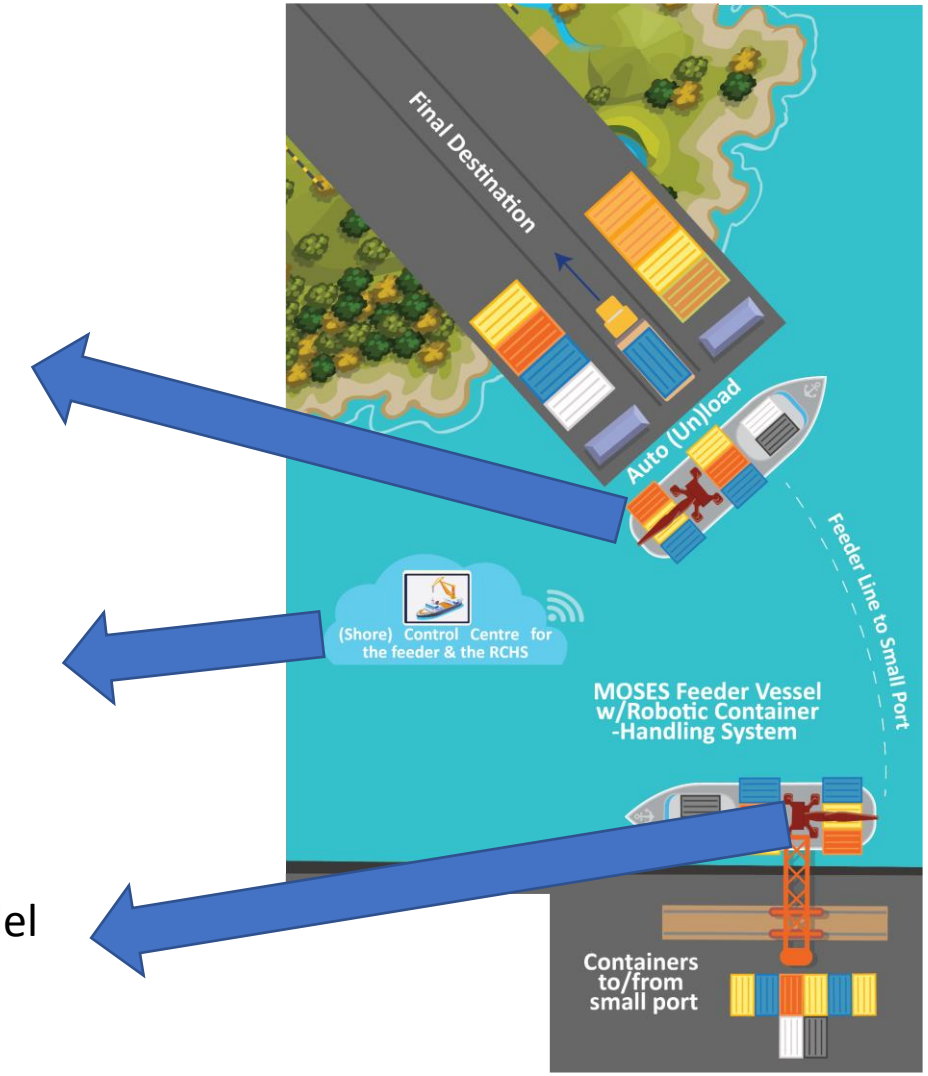
ZULU MASS

Innovative Feeder | Design and MOSES scope

- Concept design for use cases and green operation, cost analyses
- Safety related to innovative features
- Demonstration of port-to-port autonomous operation through simulation (model integration problem) +

Intelligent Operator Support System (IOSS) for autonomous cargo handling operations +

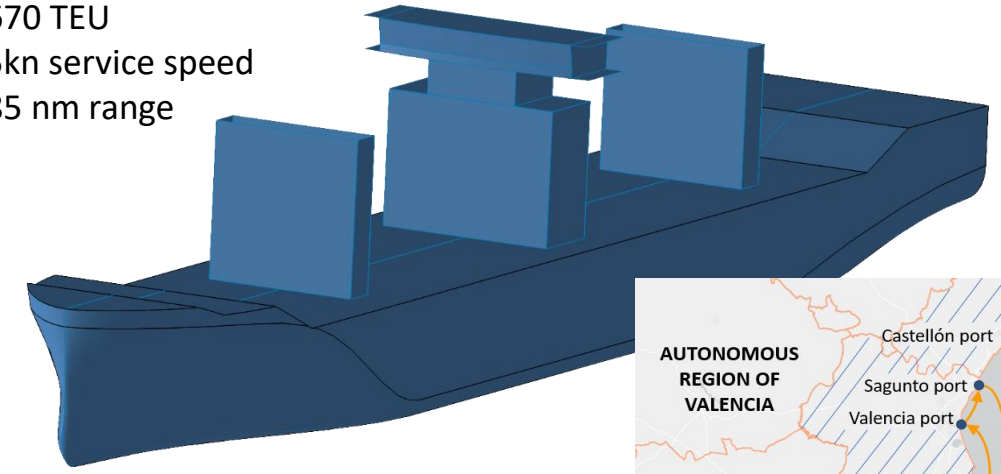
- Sensor suite for 3D world model
- Hardware for crane control



Innovative Feeder | Concept designs

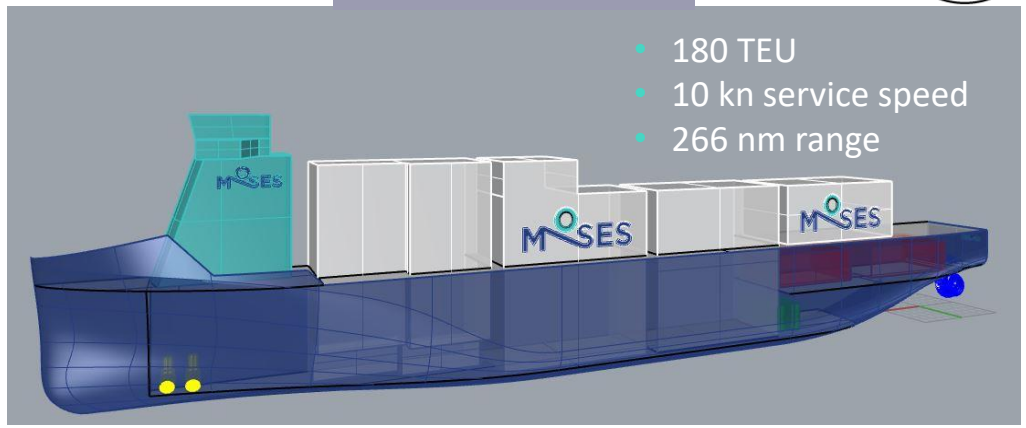
Spanish concept

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

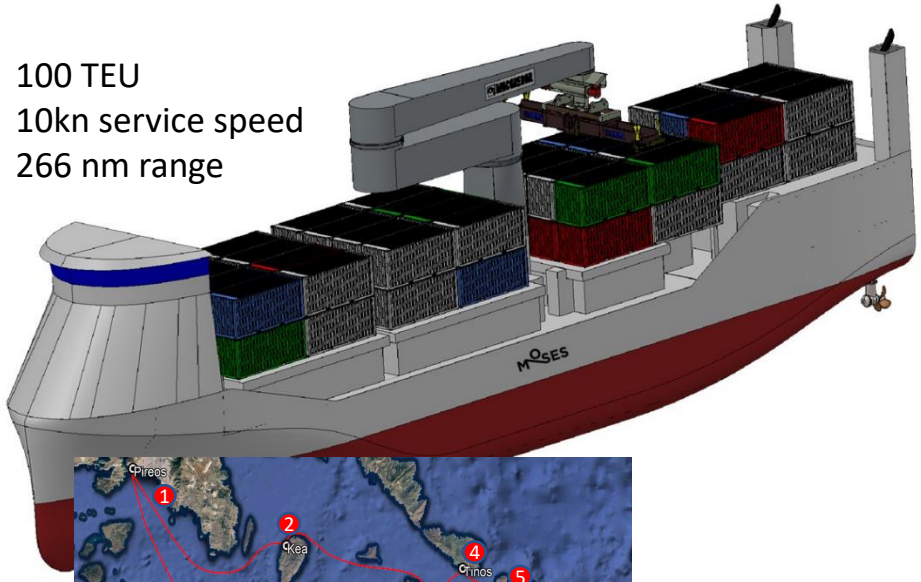


Greek concept I, II

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



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



<u>Innovations</u>:

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

Innovative Feeder | Preliminary Hazard Analysis

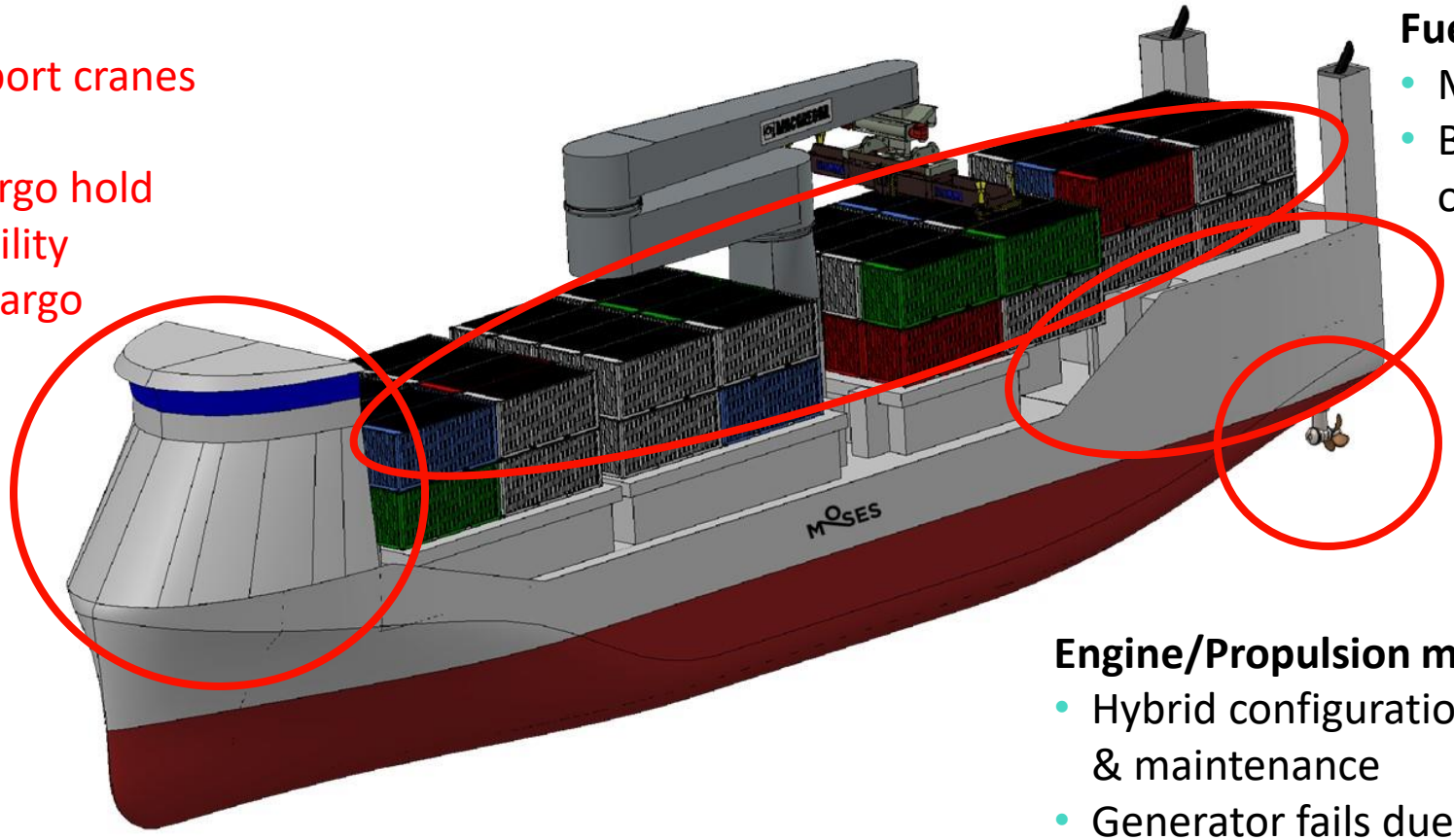
9 High risk events / system component

Cargo space:

- Onboard crane impedes port cranes → Slower cargo handling
- Water accumulation in cargo hold (open top design) → Stability degradation, damage to cargo

Accommodation:

- Mustering process takes too long
- Limited visual monitoring of the cargo space → Fire, cargo shift/loss not detected



Fuel/Energy storage:

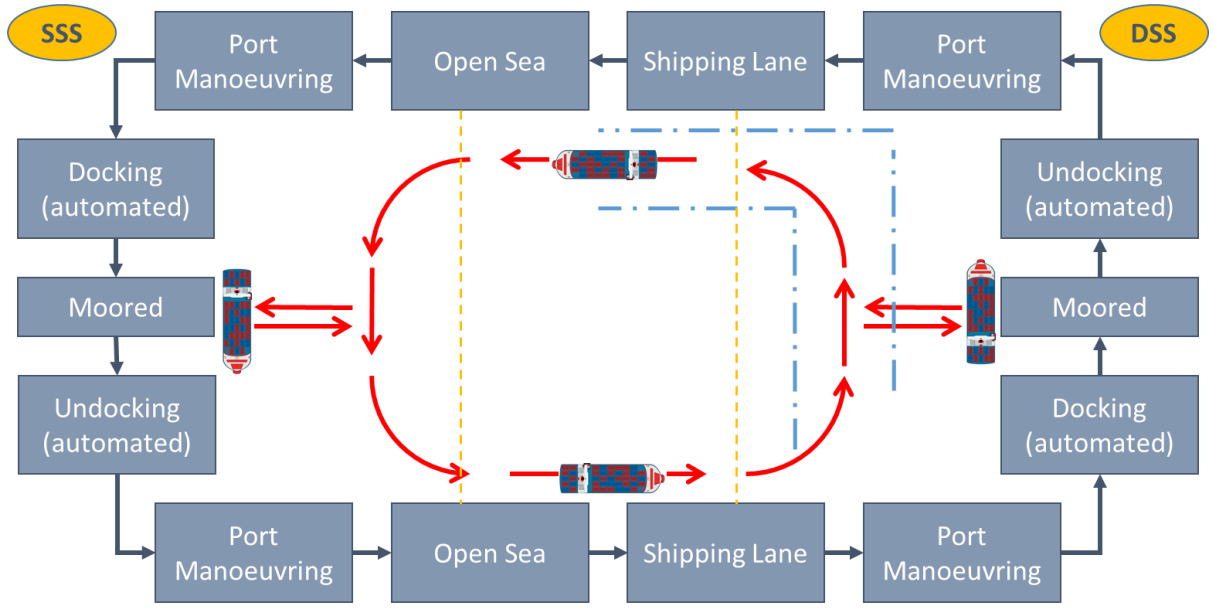
- Methanol leakage
- Batteries overheating

Engine/Propulsion machinery:

- Hybrid configuration operation & maintenance
- Generator fails due to load variations in extreme weather
- Design speed too specific

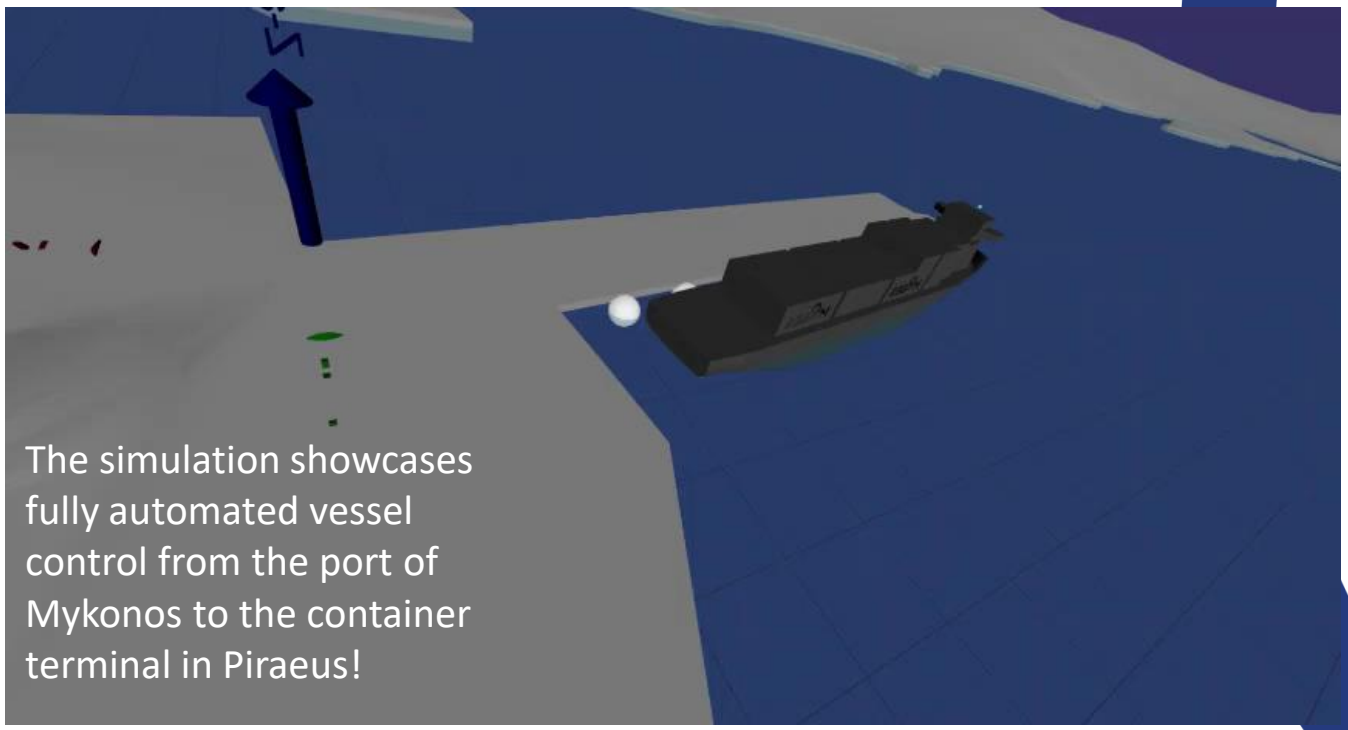
*** Hazards apply for all three concept designs**

Innovative Feeder | Autonomous round-trip simulation



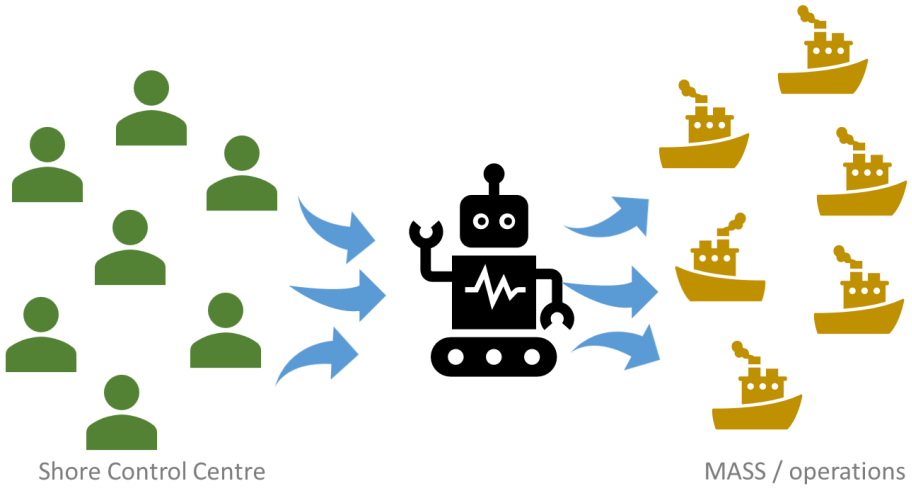
- Different models are used for
  - way-point/track following,
  - Dynamic Positioning (DP) while manoeuvring,
  - docking
- A state machine is used for changing between mission phases

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



Innovative Feeder | Robotic Cargo Handling System

Intelligent Operator Support System (IOSS):
It uses AI to solve issues caused by another AI!

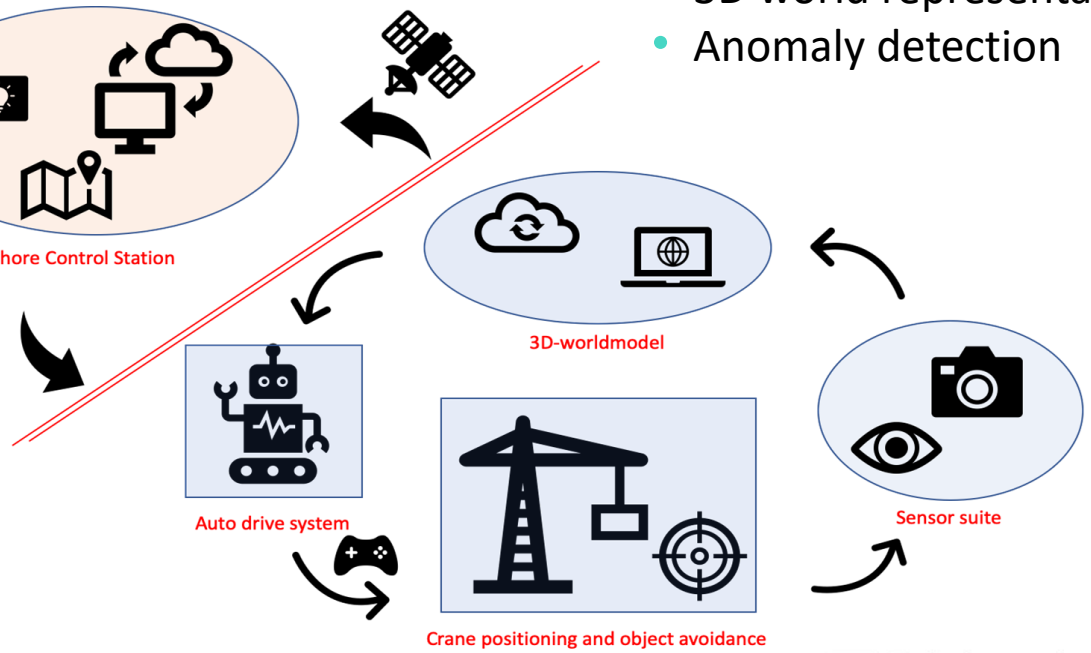


Remote supervisory control

- Enabling local situation awareness
- Robot self awareness in problem detection
- Control Intelligence
- Dynamic task allocation (One-to-many)
- Risk assessment for problem solving

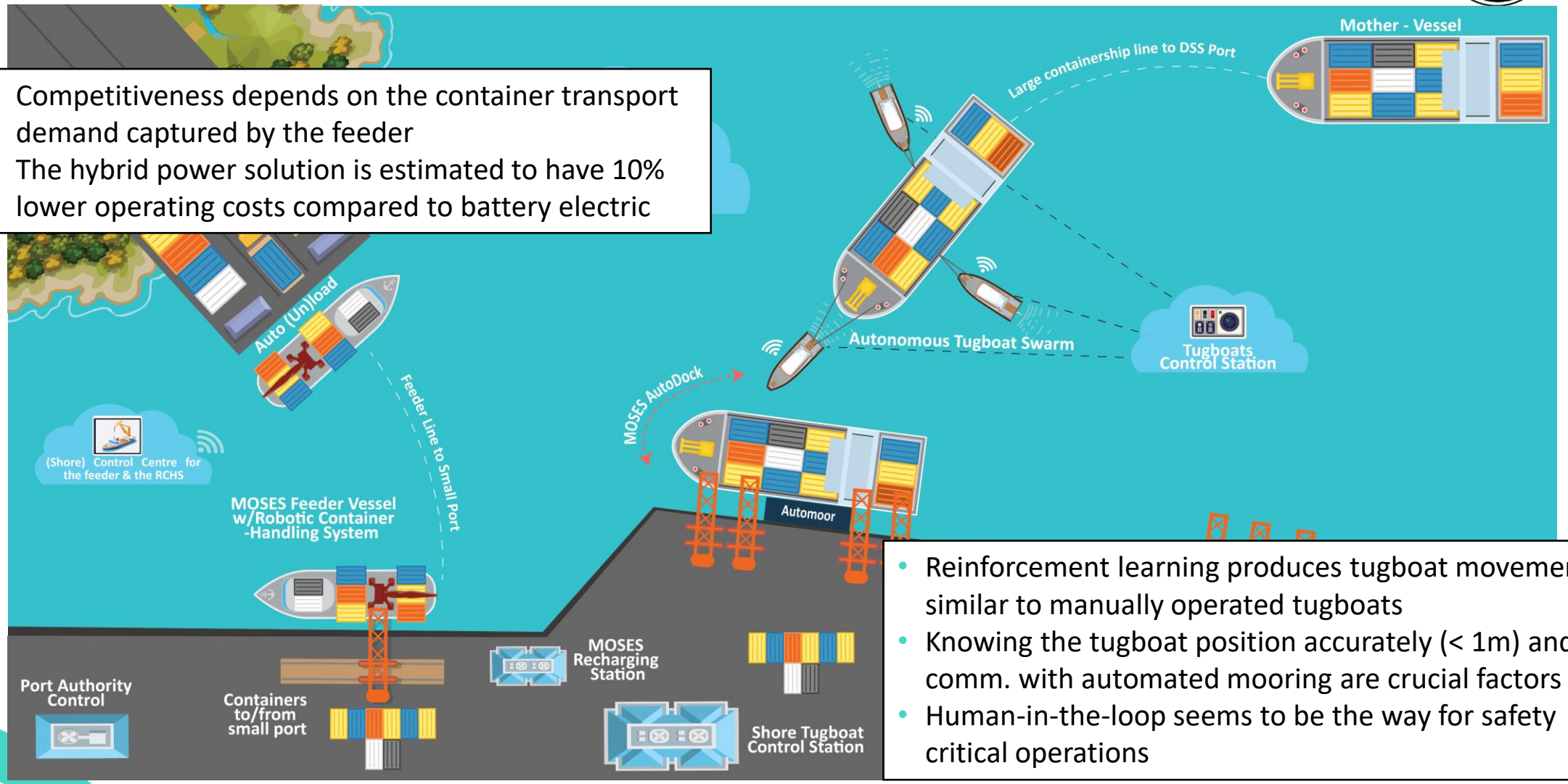
Human-robot collaboration

- 3D world representation
- Anomaly detection



MOSES experience and key take-aways

- Competitiveness depends on the container transport demand captured by the feeder
- The hybrid power solution is estimated to have 10% lower operating costs compared to battery electric



- Reinforcement learning produces tugboat movements similar to manually operated tugboats
- Knowing the tugboat position accurately (< 1m) and comm. with automated mooring are crucial factors
- Human-in-the-loop seems to be the way for safety critical operations

NAIADES III Impact Map

Strong direct impact

Direct impact

Indirect impact

Inland Navigation Week

shifting freight to water

Innovative feeder *designed to be competitive to RoRo chain and independent from small port infrastructure (cargo, mooring)*

Matchmaking platform *optimises SSS alternative for stakeholders*

more attractive jobs

Intelligent Operator Support System (IOSS) *enabling safe and cost-effective (1-many) remote crane operations*

pathway to zero emission fleet

Innovative Feeder *designed for zero-emissions operation*

Required infrastructure for recharging fully electric ***tugboats***

smart waterways

Autonomous port-to-port operation of ***Innovative Feeder***

Fully automated ***tugboat*** *operation (manoeuvring)*

www. moses-h2020.eu

MOSES project2020

@mosesproject20

MOSES Project

Thank you for your attention!

Konstantinos Louzis, NTUA

klouzis@mail.ntua.gr

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