Automated Vessels and Supply Chain Optimization for Sustainable Short Sea Shipping

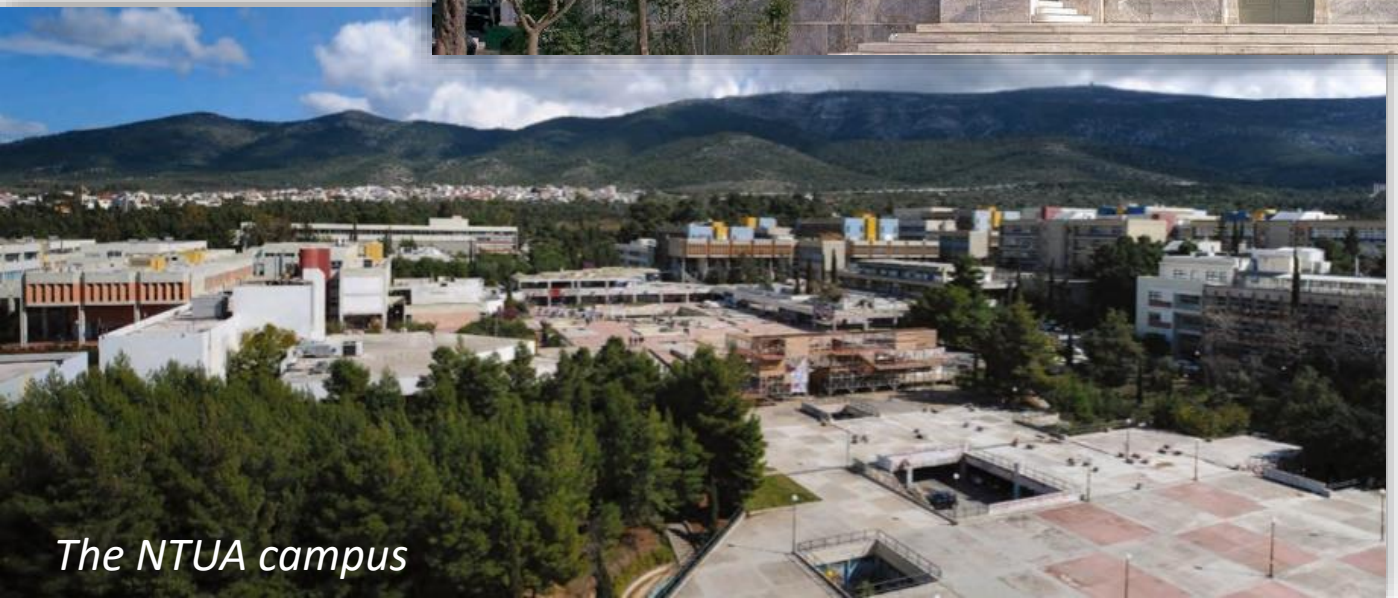
The MOSES project results

Konstantinos Louzis, NTUA

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

26/9/2024

The National Technical University of Athens



The NTUA campus

- Est -

1837

Seakeeping Basin
School of Naval Architecture & Marine Engineering

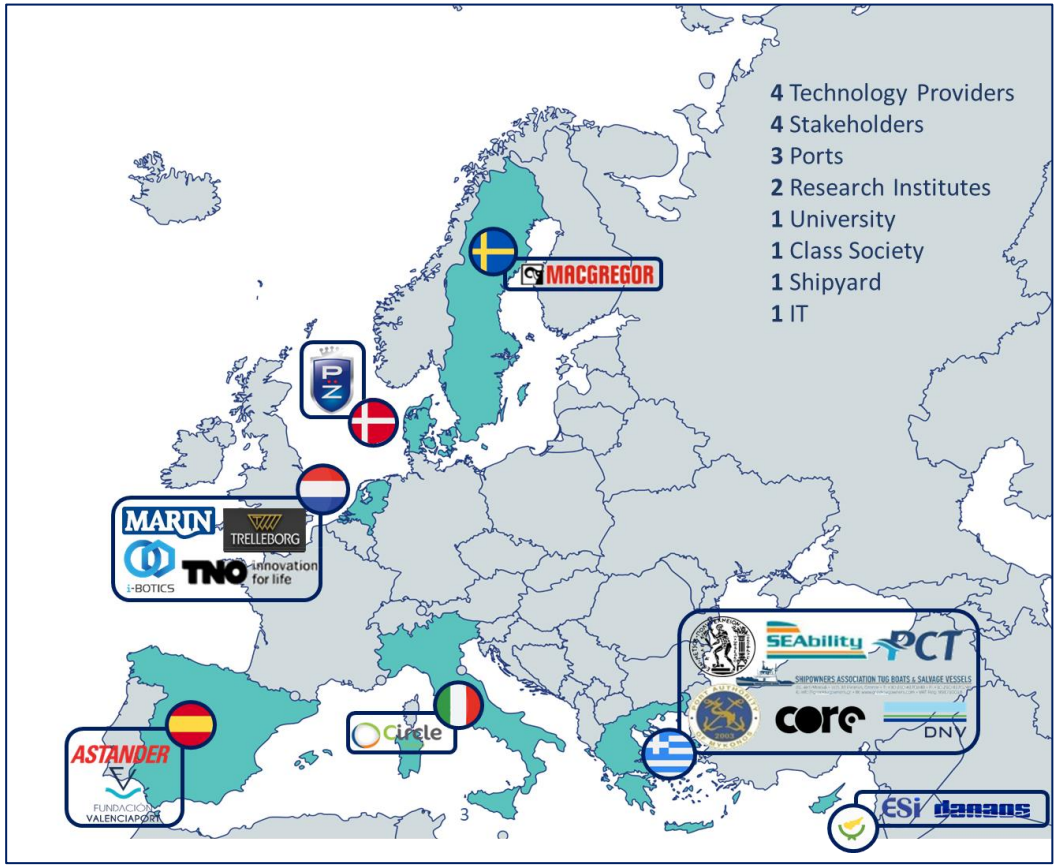
The Maritime Risk Group

- ***A research group*** within the School of Naval Architecture & Marine Engineering @*NTUA*
- ***Areas of expertise:***
  - Maritime safety & transport
  - Risk analysis and assessment, risk based design
  - Human element
  - Resilience & systems engineering
  - Autonomous shipping
  - Environmental engineering
- ***Coordination and participation in major national, EU and regional research and innovation projects***

MARITIME RISK GROUP

Facts about the MOSES project

- **Title:** AutoMated Vessels and Supply Chain Optimisation for Sustainable Short Sea Shipping
- **Duration:** 01.07.2020 - 30.06.2023 (36 months) + 6 month extension
- **Funding scheme:** RIA – Research and Innovation Action
- **EU contribution:** EUR 8 122 150
- **17 Partners** across Europe
- **Coordinated by:** National Technical University of Athens (NTUA), Greece



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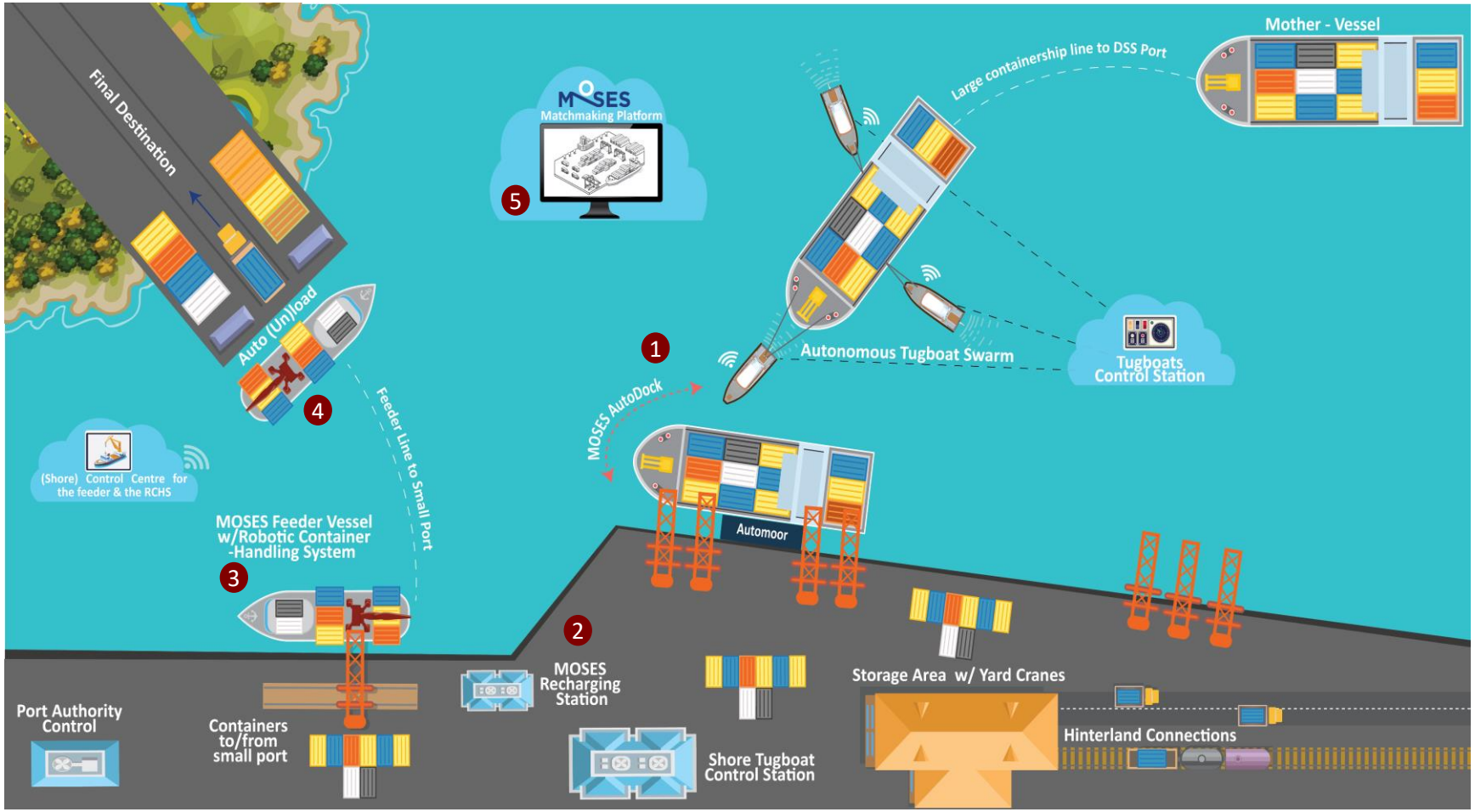
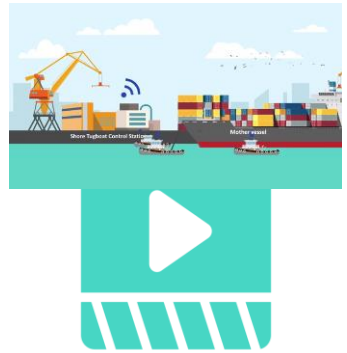
MOSES aims to…

AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

Create sustainable feeder services from large container terminals to **small ports with no infrastructure to replace trucks on Ro-Ro ships**

MOSES Concept & Innovations



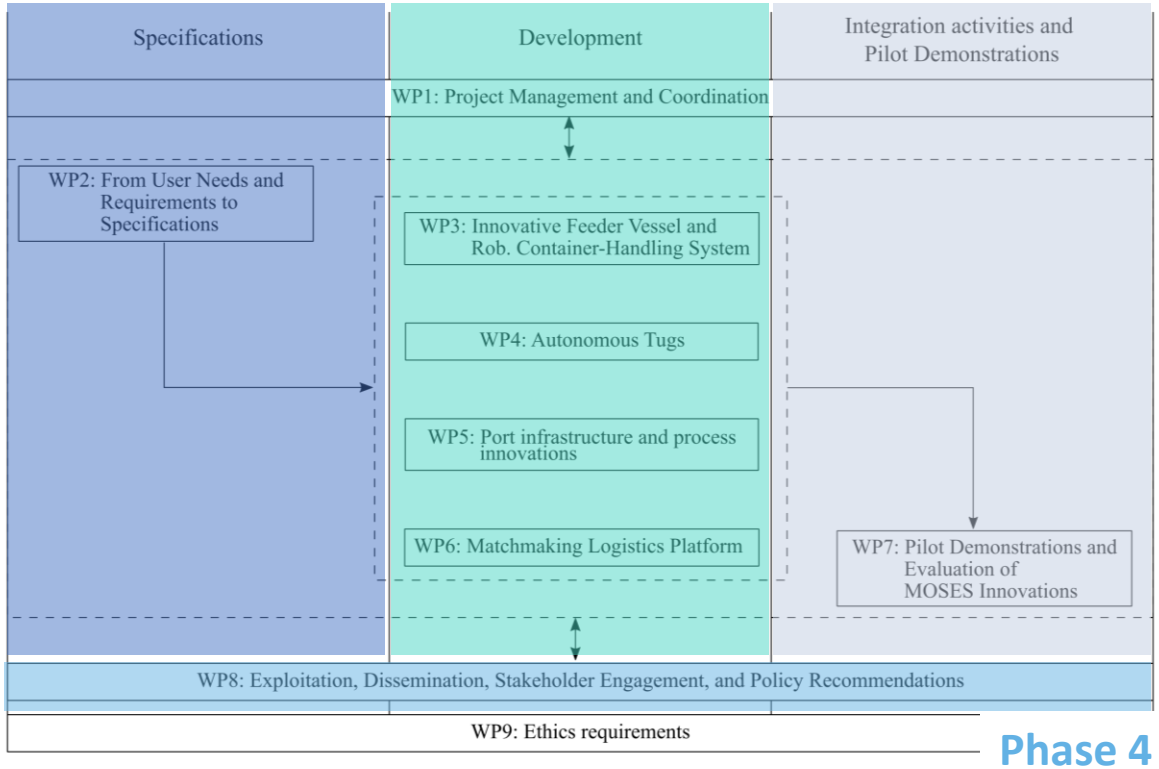


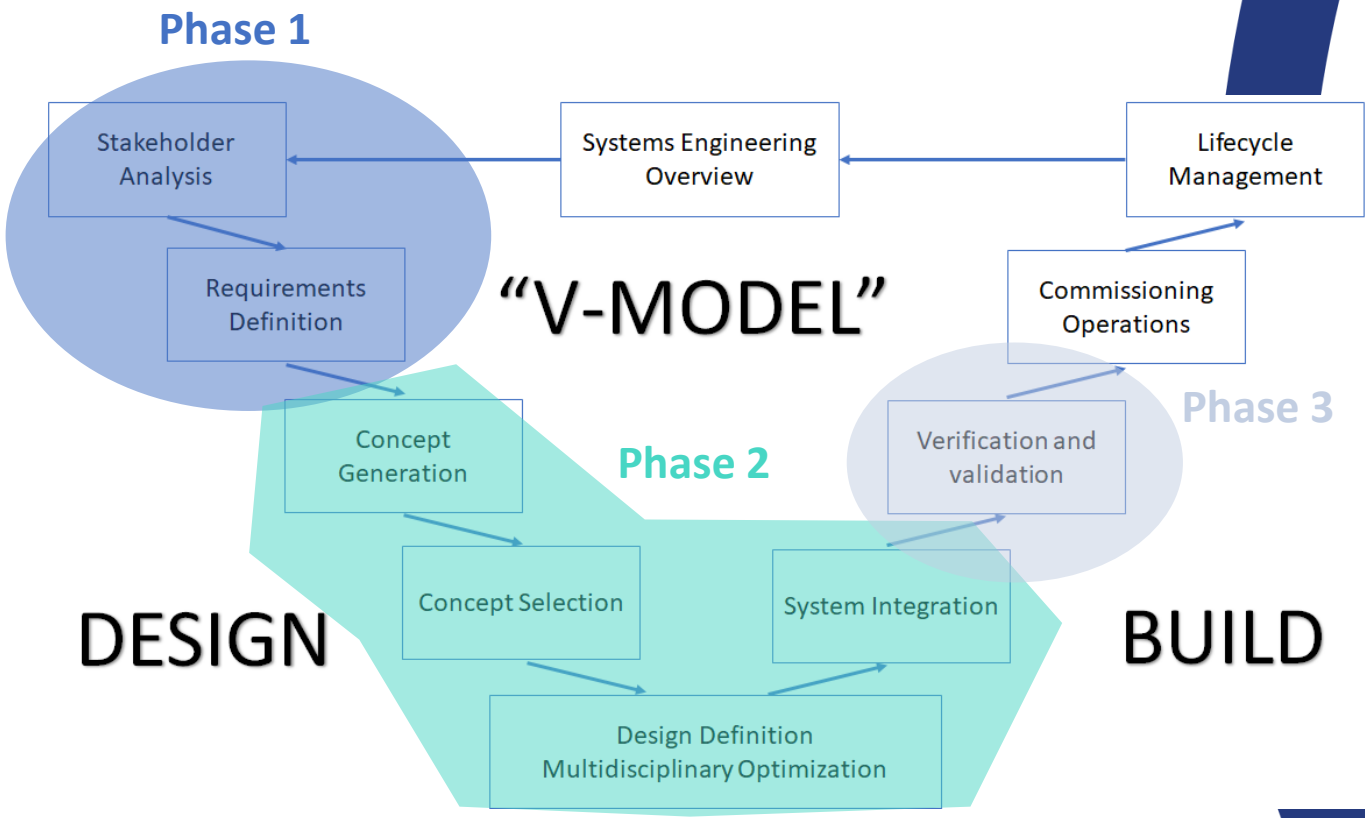
https://youtu.be/aJyJknqoufc

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**

The 4 phases of MOSES development





MOSES V-model development (MARIN, D3.1)

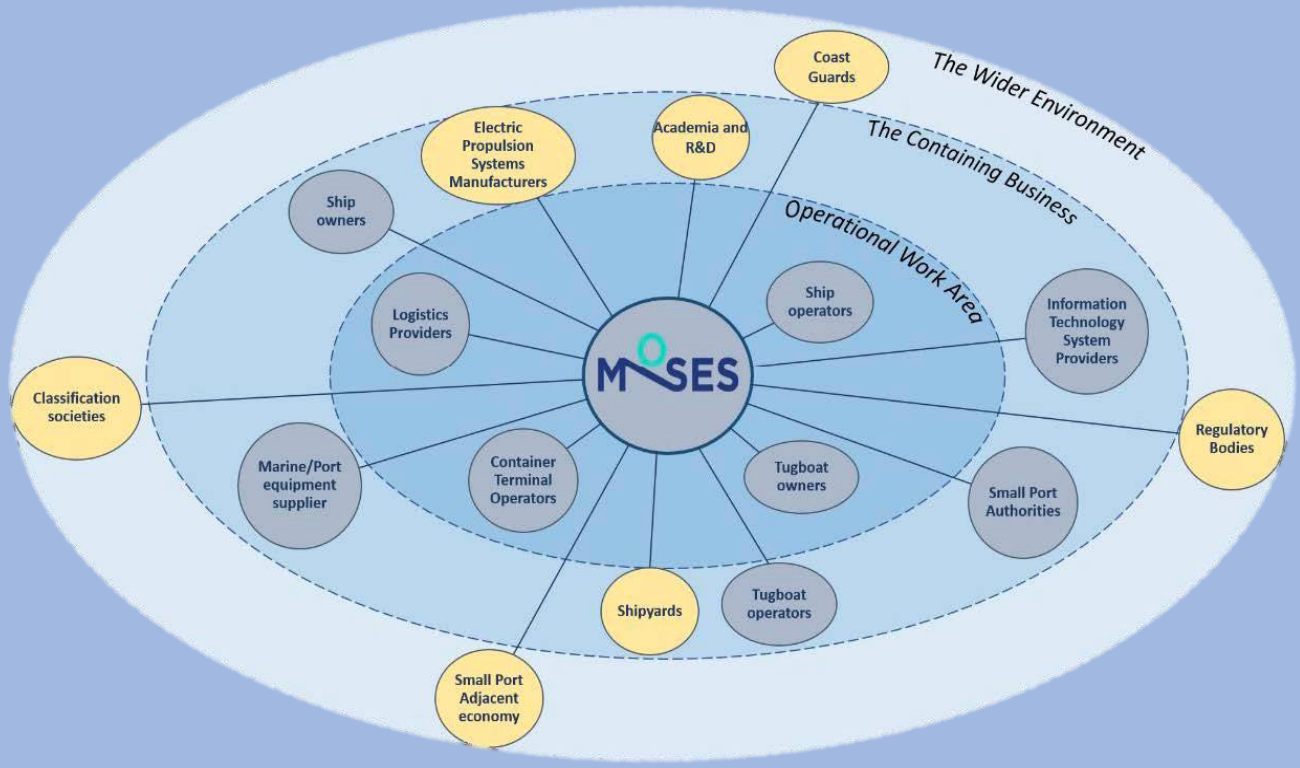
<u>User-driven development</u>:
Reflecting "the importance of involving end-users in the research and development of new technologies"

(EU Green paper on Innovation, 1996)

The MOSES approach and research questions

System goals
Requirements
Operational context

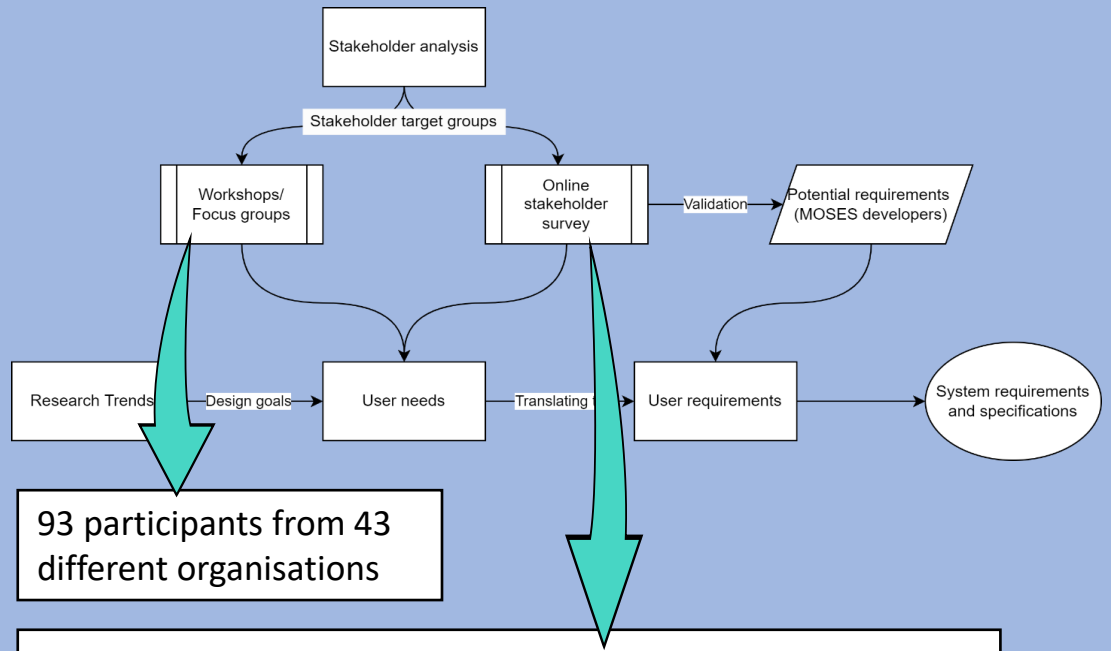
Who are the MOSES stakeholders?



The MOSES approach and research questions

System goals
Requirements
Operational context

What do the stakeholders consider important?



A sample of what the stakeholders said

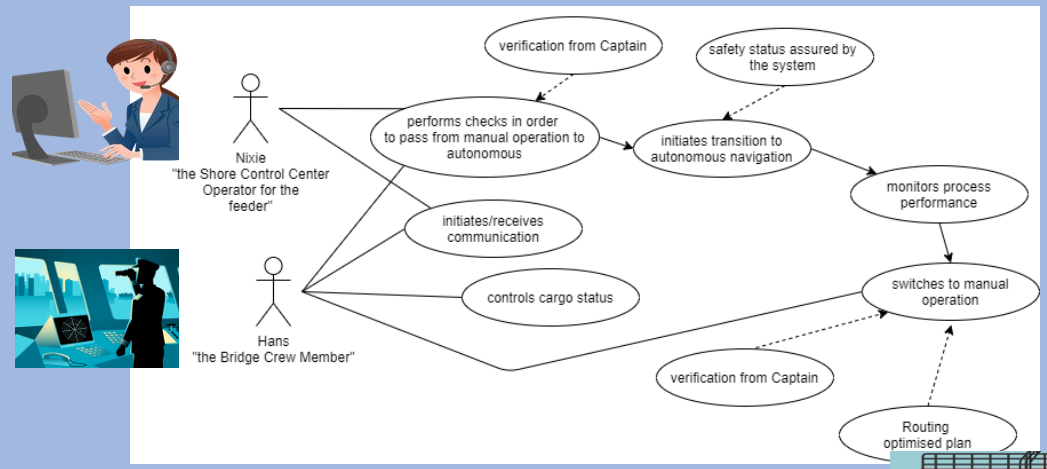
- 63% — MOSES innovations should be **cost effective**
- 93% — The feeder should have **significantly reduced environmental footprint**
- 86% — The automated crane should **operate in similar conditions** as a manual crane
- 80% — The autonomous tugboat swarm should **transmit logs in real-time**
- 58% — The matchmaking platform should **efficiently manage empty containers**

* % of respondents that rated the requirements fairly or very important

The MOSES approach and research questions

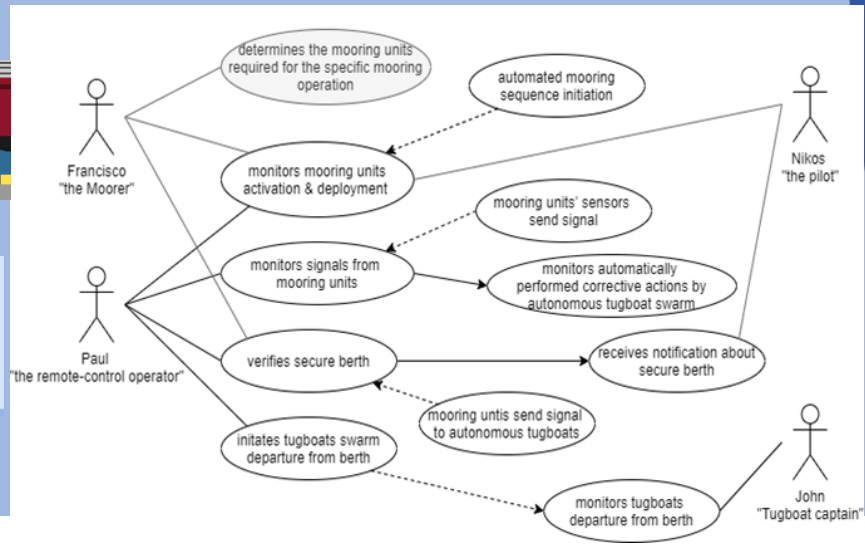
System goals
Requirements
Operational context

How will the innovations be used, and which actors are involved?



Sea passage
(autonomous navigation)

Approaching a DSS port
(mother vessel mooring process)



The MOSES approach and research questions

System goals
Requirements
Operational context

What are the conditions for the MOSES feeder services to be competitive?

Western MED - Spain
Decongest truck transport traffic in ***Valencia*** port and connect it to ***Sagunto*** and ***Gandia*** satellite ports

Financial analysis that compares the costs of the **MOSES Lo-Lo chain with the land-based alternatives**

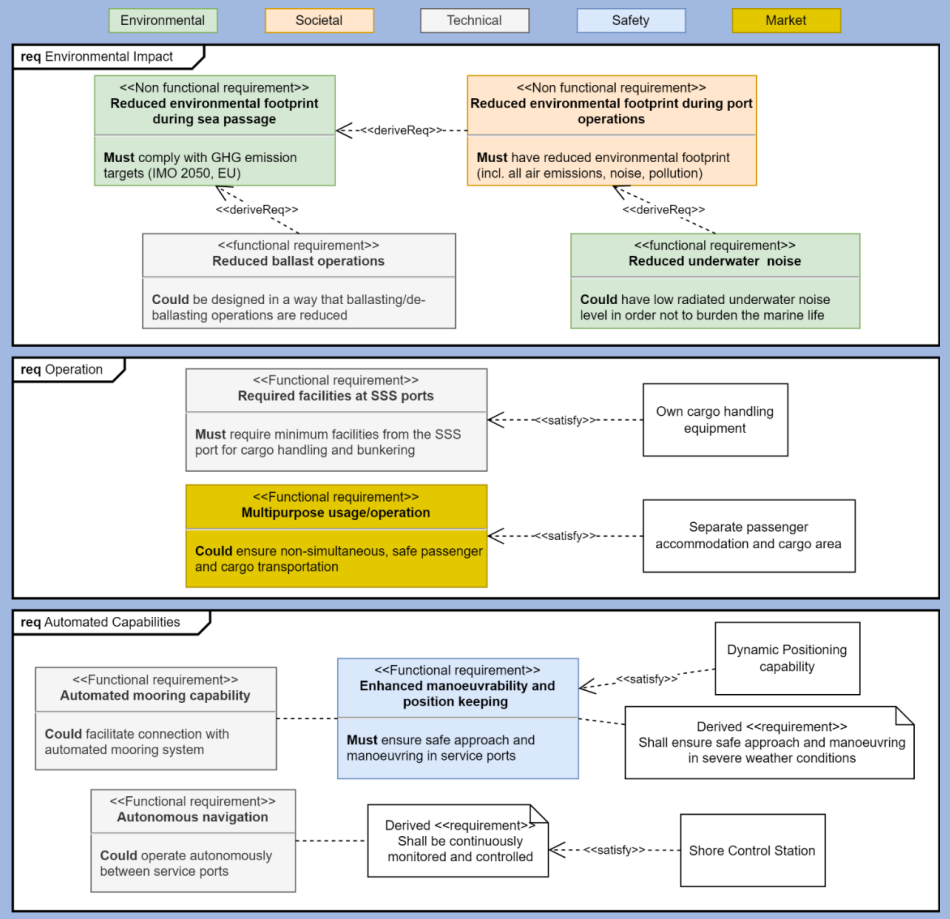
At this early stage, many assumptions had to be made!

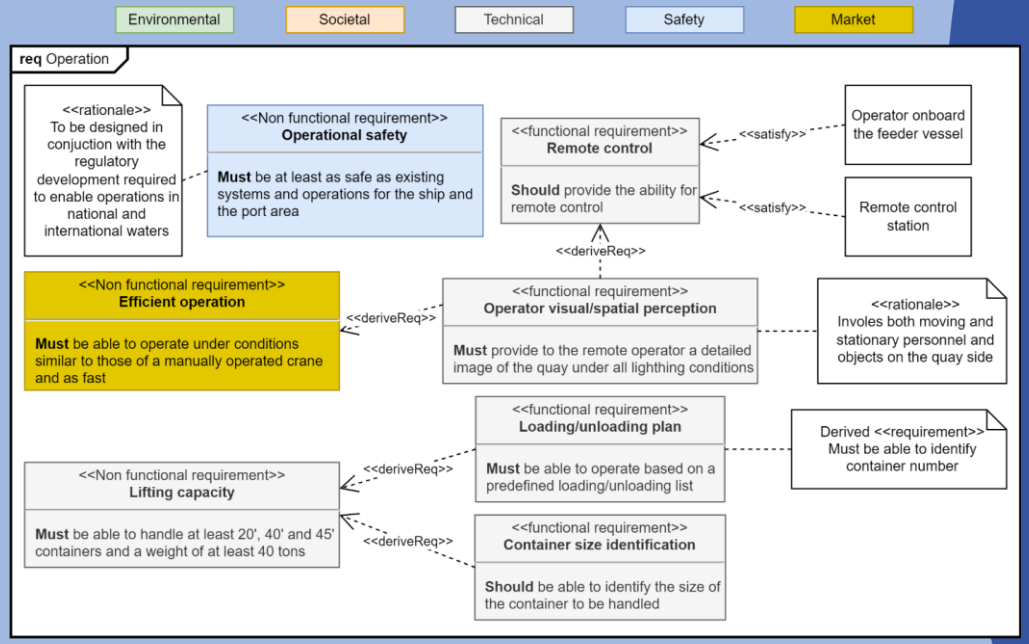
Eastern MED - Greece
Decongest ***Piraeus*** container terminal and integrate ***small Greek ports*** into the container supply chain

The MOSES approach and research questions

System goals
Requirements
Operational context

How should the MOSES innovations work within their operational context?



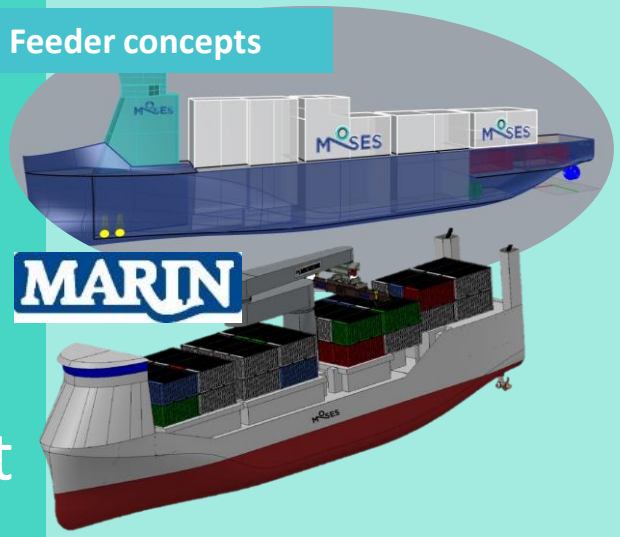


The MOSES approach and research questions

How should the MOSES innovations be designed to accomplish their goal?

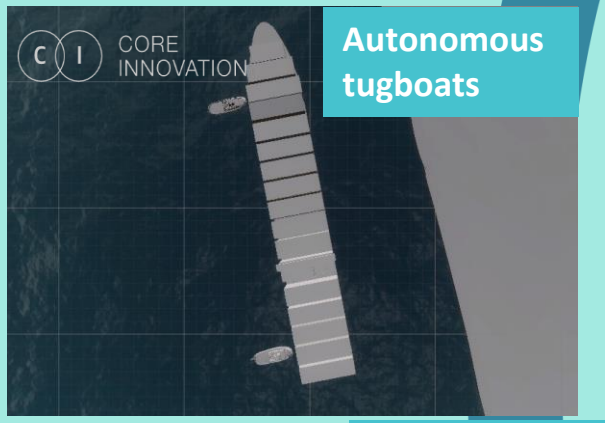
Technical Development

Feeder concepts

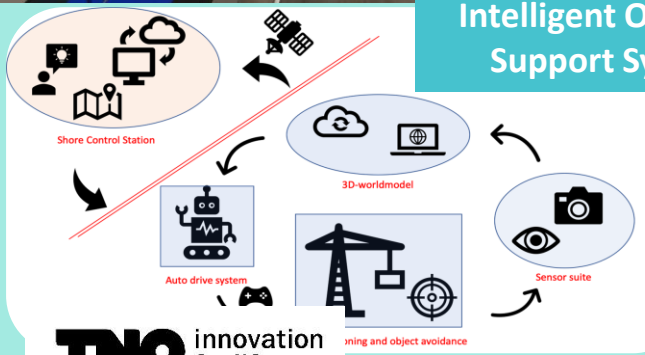


Automated crane

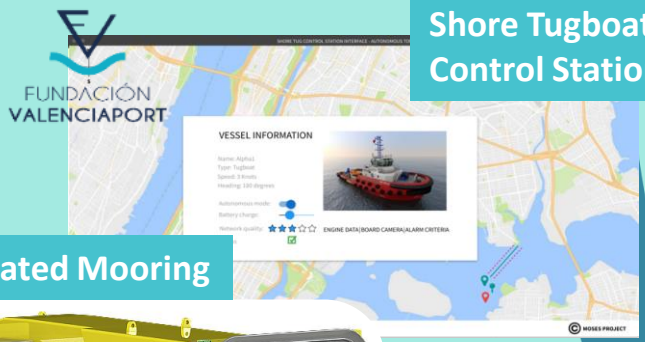
Autonomous tugboats



Intelligent Operator Support System



Shore Tugboat Control Station



Matchmaking Platform

Automated Mooring

This phase included desktop studies and simulations that **validated some aspects of the innovations**

The MOSES approach and research questions

Integration Pilot Demos Validation

The “experiments” in this phase **validated some aspects of the innovations**

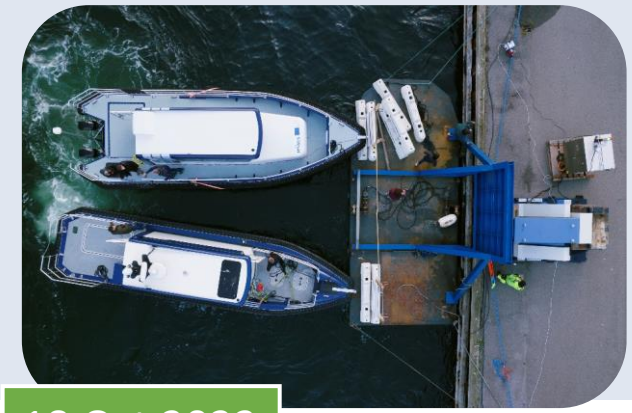
How do the innovations perform?

Pilot demonstration #1

Autonomous “tugboat swarm” and automated docking

Denmark

https://youtu.be/28P-BRpVXRY



18 Oct 2023

Pilot demonstration #2

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

Netherlands

https://youtu.be/9i7pQolgwxU

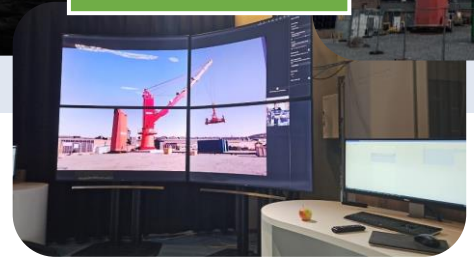
14 Sep 2023

Pilot demonstration #3

Autonomous operation of the Robotic Container-Handling System and remote monitoring with the IOSS

Sweden, Netherlands

https://youtu.be/bwkitTy5Kpw
https://youtu.be/0TD2AShN2e8



28 Sep 2023

The MOSES approach and research questions

Integration
Pilot Demos
Validation

What is the impact of the MOSES innovations?

Evidence from the:
1. technical development
2. pilot demos

MOSES
Sustainability Framework

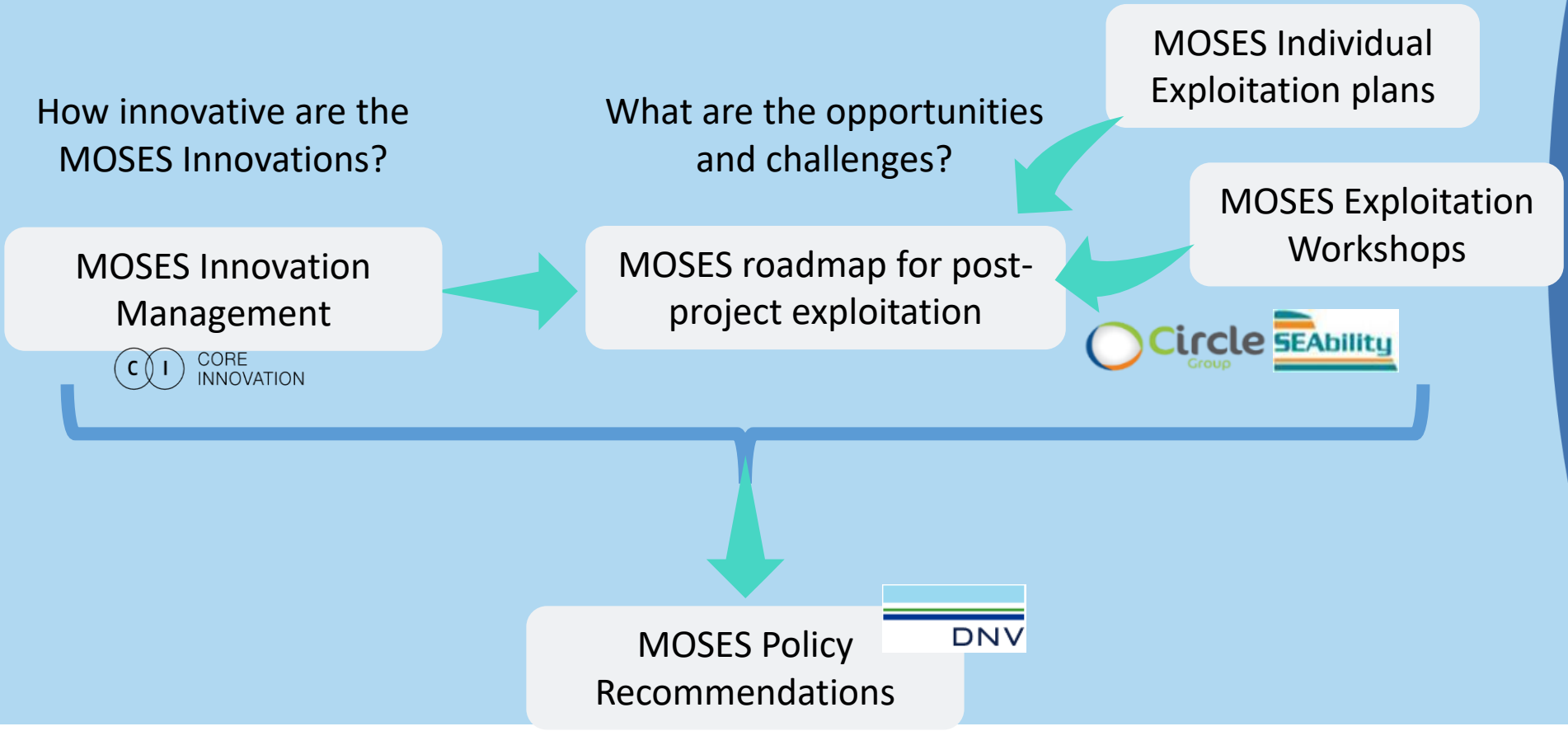
- Finalising the list of success indicators
- Determining baselines and comparing

- Quantifying the benefits of the innovations
- Measuring the project's success vs. its objectives

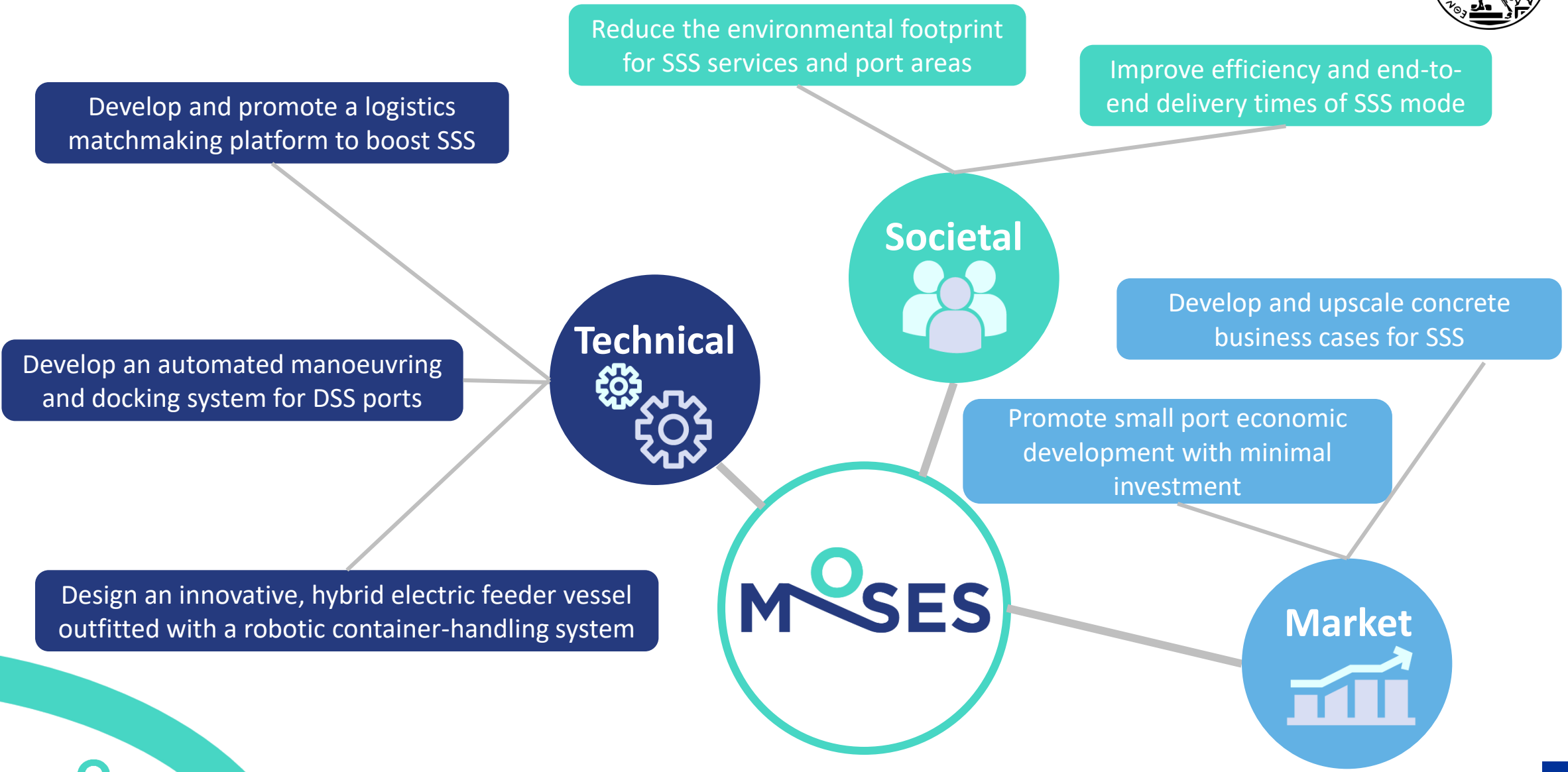
The MOSES approach and research questions

Innovation Exploitation Policy Recommend.

What are the next steps for the MOSES innovations?

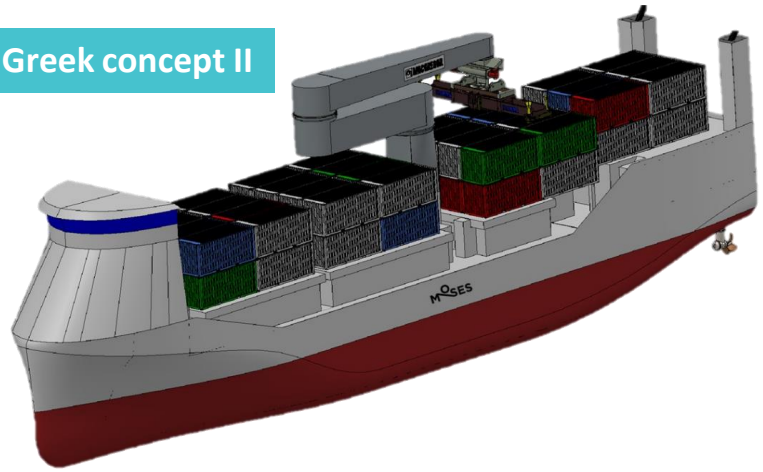


Did we achieve our objectives?



Did we achieve our objectives?

Greek concept II



- Near zero operational emissions through **sustainable propulsion** (Methanol hybrid, fully electric)
- **"Greener"** than land-based alternatives

- **Competitive** to existing transport alternatives
- Can replace **> 40% existing Ro-Ro traffic** used to transport containers on trailers
- Enables **small port engagement** in EU container supply chain

- **Does not require CAPEX** for cargo-handling infrastructure at port
- **Reduces operational port-related costs** (no pilotage and tugboats, no stevedoring)
- **Enhanced manoeuvrability** with thrusters and DP allow faster time to berth
- Free-up **usage time of port cranes** in DSS ports

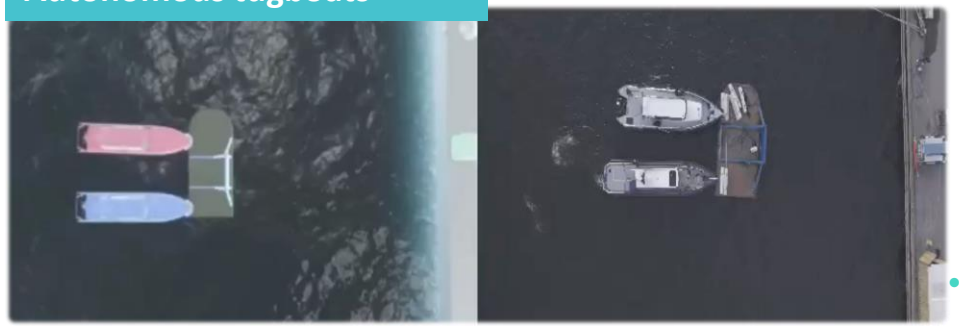
Design an innovative, hybrid electric feeder vessel outfitted with a robotic container-handling system

Improve efficiency and end-to-end delivery times of SSS mode

Reduce the environmental footprint for SSS services and port areas

Did we achieve our objectives?

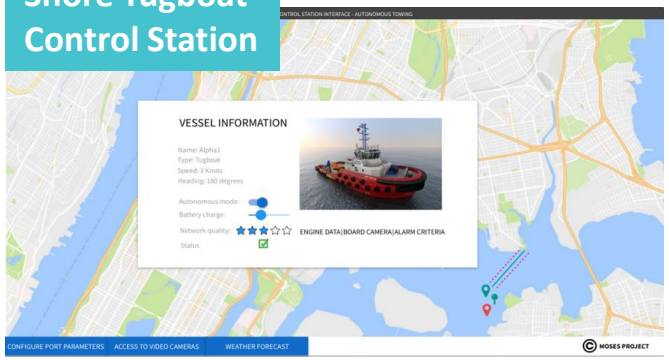
Autonomous tugboats



Reduced tugboat operational time means less air pollutants at port

- Potential to **reduce human-error related** tugboat accidents (e.g. due to miscommunication) and mooring-related accidents
- Automated processes mean up to **24/7 service availability at port**

Shore Tugboat Control Station



- Reduced manoeuvring and docking time means **less OPEX and more resource availability** to handle more traffic
- **Cargo can be transited faster** from the mother vessel to the feeder

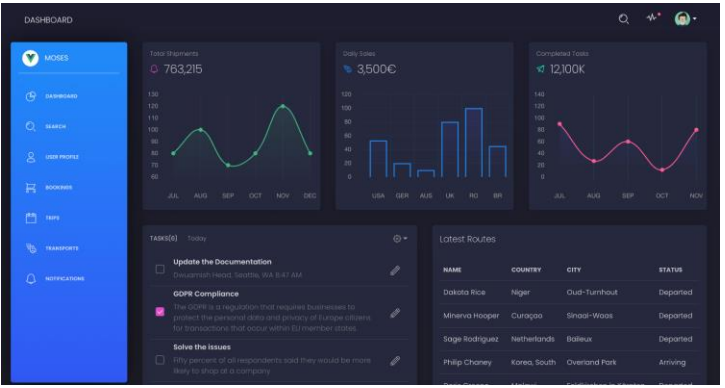
Automated Mooring

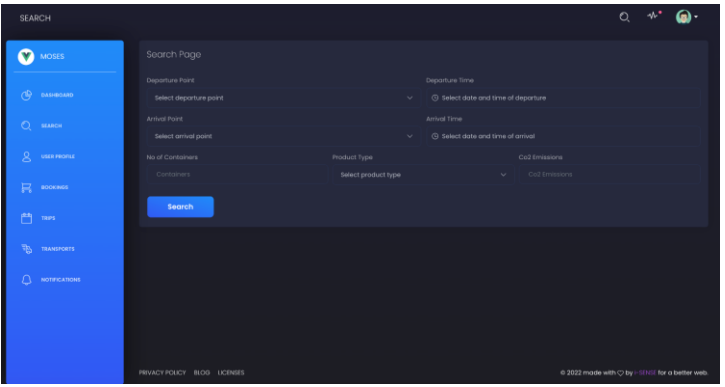
Develop an automated manoeuvring and docking system for DSS ports

Improve efficiency and end-to-end delivery times of SSS mode

Reduce the environmental footprint for SSS services and port areas

Did we achieve our objectives?





Contributes to **reducing air pollutants and perceived noise** due to container-hauling trucks near ports

- **Improves modal shift to SSS** in designated areas (18% of road transport cases have an SSS alternative)
- Contributes to **reducing road traffic congestion** due to container-hauling trucks near ports

Improves backhaul traffic for platform subscribers by **reducing empty container trips** performed by road

Develop and promote a logistics matchmaking platform to boost SSS

Improve efficiency and end-to-end delivery times of SSS mode

Reduce the environmental footprint for SSS services and port areas

Did we achieve our objectives?

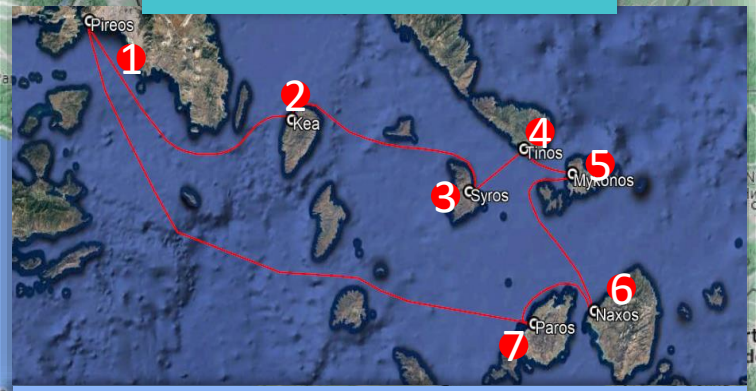
Western MED-Spanish case

Competitiveness assumptions:

- **40% of the maximum estimated demand** is captured
- > **three weekly services** in each port
- Cost-effective vessel capacity **600 – 700 TEUs**
- **5 kn service speed**
- **3 truck haulages / day** to hinterland

Valencia → Sagunto: -3.7% / cargo unit
Valencia → Gandia: -10.6% / cargo unit
Compared to road transport

Eastern MED-Greek case



Competitiveness assumptions:

- **80% of the maximum estimated demand** is captured
- > **two weekly services** in each port
- Cost-effective vessel capacity **approx. 100 TEUs**
- **10 kn service speed**

-3.5 % cost / cargo unit
compared to Ro-Ro chain

Develop and upscale concrete business cases for SSS

Did we achieve our objectives?

EU ports able to host container feeder vessels ⬆ **10%**

Increase of EU port able to host container feeder vessels

MOSES feeder vessel offering complete independence from port infrastructure

Infrastruct. investment for small ports **< 250k EUR**

An SSS market analysis in the EU identified **14 potential use cases*** for the MOSES sustainable feeder services

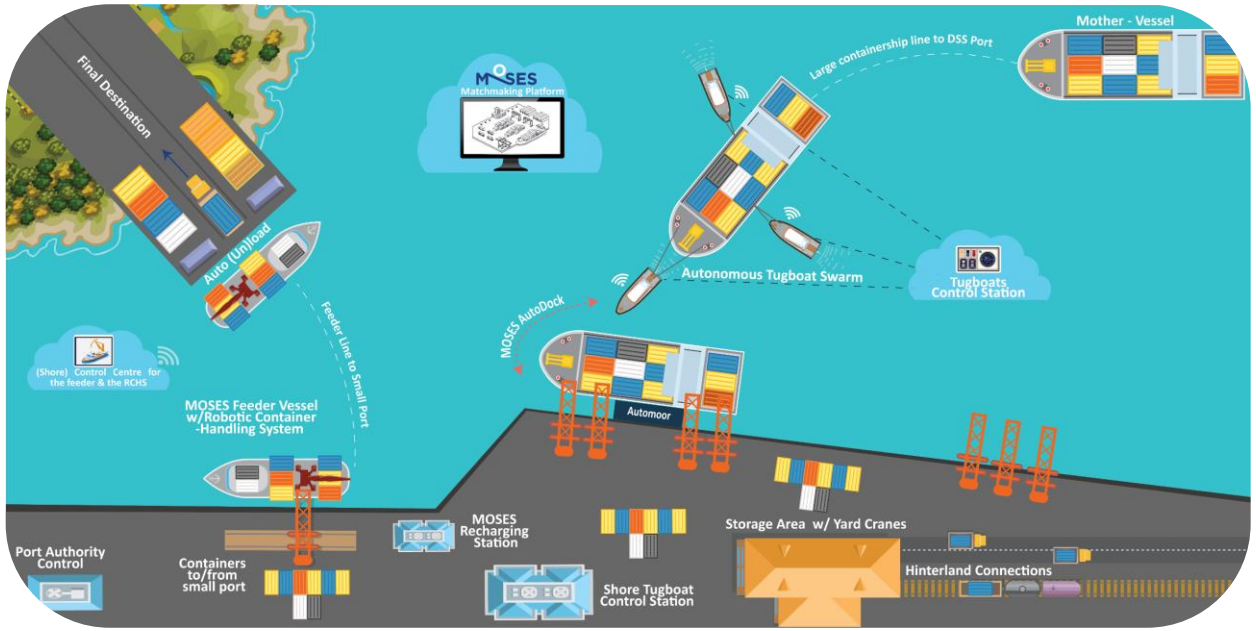
* small ports that currently do not serve container traffic in the vicinity of 20 large container terminals

The combined operation of the MOSES Innovative Feeder vessel with the onboard automated Robotic Container-Handling System **does not depend on port infrastructure and personnel**

Small ports require **0 EUR investment** to serve the MOSES Innovative Feeder

Promote small port economic development with minimal investment

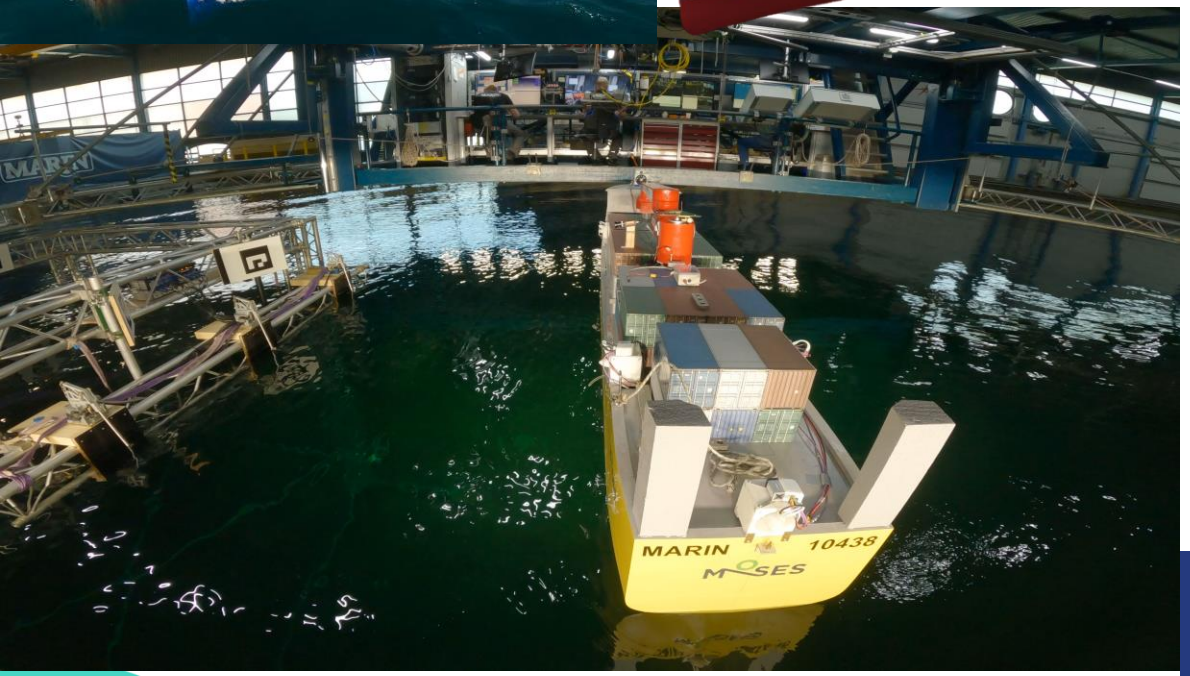
What have we learned?



For the business cases and the feeder service

- There is a **significant number of small ports that can be integrated in the EU container supply chain** through the MOSES innovations
- Competitiveness depends on the **container transport demand captured** by the feeder:
  - Lower expected demand → Higher % captured for the MOSES service to be competitive
- The MOSES service **can contribute to modal shift** because it can be competitive to existing alternatives (Trailer trucks on Ro-Ro, Trucks on road)

What have we learned?



For the MOSES Innovative Feeder and Robotic Container-Handling System

- Significantly **lower cargo capacities** (vs. conventional container feeders) are cost-effective.
- The hybrid power solution is estimated to have **10% lower operating costs** compared to fully electric.
- Charging a fully electric feeder at the large container terminal is **technically and economically feasible**.
- **Fully autonomous, port-to-port operation is technically feasible** and could be an advantage due to less human resources required.
- The automated crane **may be faster** than a human-driven crane.

Future Research

- **Safety studies for autonomous operation** are needed.
- Reliability of RCHS and behaviour in harsh weather conditions.

What have we learned?

For the MOSES AutoDock System

- **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.
- **Integration with existing control systems** is challenging.

Future Research

- **Safety studies for autonomous operation** are needed (introducing failures in training).
- Increase the **scope of training scenarios** (weather, port traffic, night-time operation.
- **Integration** in port operations.

Challenges ahead!

The MOSES feeder service, enabled by the MOSES innovations seems to be a promising and sustainable idea…

End-user Engagement

- **Shipowners willing** to build and operate the innovative feeder vessel.
- **Cargo owners willing** to use the feeder instead of trucks on Ro-Ro.
- The benefits of the MOSES innovations need to be **clearly communicated to stakeholders**.

Supply chain integration

- A way to achieve cost-effective **last mile transportation** at the islands.

Innovation uptake

- **Industrial partnerships** are crucial for scaling up the MOSES innovations.
- **Different business models** need to be developed (e.g. to account for alternative ways to consolidate general cargo into containers)

QUESTIONS?

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

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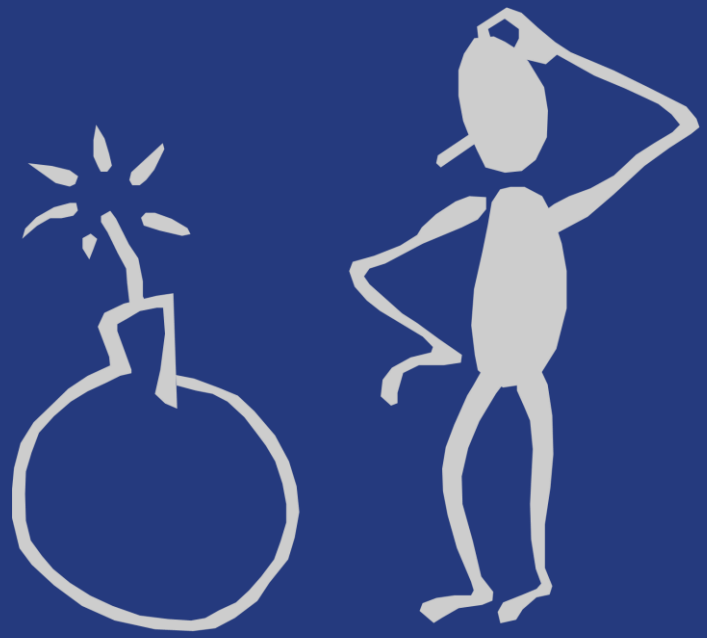

Thank you!

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MOSES project2020

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MOSES Project

Thank you for your attention!

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