



AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

D.2.2: MOSES Use Cases and scenarios

Document Identification			
Status	Final	Due Date	Thursday, 31 December 2020
Version	1.0	Submission Date	Friday, 12 February 2021
Related WP	WP2	Document Reference	D.2.2
Related Deliverable(s)	D2.1	Dissemination Level	PU
Lead Participant	SEAB	Document Type:	R
Contributors	NTUA, TNO, DANAOS, MARIN, SAT, CORE, VPF, CIRCLE, TREL, TUCO, MCGRSWE, MHM, PCT	Lead Author	Eleni Krikigianni (SEAB)
		Reviewers	Mercedes de Juan Muñoyerro (VPF) Reza Karimpour (CIRCLE)



Document Information

List of Contributors		
First Name	Last Name	Partner
Alessandro	Zanderigo	TRELL
Alexio	Picco	CIRCLE
Casper	Vetke Clausen	TUCO
Charis	Oikonomidou	NTUA
Christos	Polalis	NTUA
Elena	Krikigianni	SEAB
Evangelia	Latsa	SEAB
Fotis	Oikonomou	DANAOS
George	Pedakakis	PCT
Gerco	Hagesteijn	MARIN
Hans	Cozijn	MARIN
Hans	van den Broek	TNO
Ilias	Kotsidis	ESI
Janne	Suominen	MCGRSWE
Jasper	van der Waa	TNO
Jason	Vlavianos	SAT
Konstantinos	Nikolopoulos	CORE
Konstantinos	Louzis	NTUA
Konstantinos	Naskou	NTUA
Maria	Kotoula	MHM
Michael	Kotras	PCT
Nikolaos	Vardalachos	MHM
Nikos	Themelis	NTUA
Mercedes	de Juan Muñoyerro	VPF
Mirjam	Huis in 't Veld	TNO
Reza	Karimpour	CIRCLE
Stavros	Tsagalas	PCT
Vasiliki	Palla	SEAB

Document History			
Version	Date	Change editors	Changes
0.1	05/10/2020	SEAB	ToC creation
0.2	19/10/2020	SEAB	Input on sections 1-3
0.3	02/12/2020	MARIN, TUCO, TNO	Comments on D2.2, refinements on chapters 2 & 3
0.4	07-10/12/2020	SEAB, MARIN, VPF, SAT, CORE, DANAOS, NTUA, TNO, MHM	Input on chapters 4 & 5
0.5	05-26/01/2021	SEAB, CIRCLE, DANAOS, VPF, NTUA, TNO, TREL, MARIN, PCT	Refinements on chapter 4 and remarks for chapters 5 & 6
0.6	26/01/2021	SEAB	UML creation
0.7	03/02/2021	SEAB, NTUA, MARIN	Refinements on chapter 5
0.8	03-08/02/2021	SEAB, TNO, NTUA, DANAOS, MCGRSWE, ESI	Refinements on chapters 5 & 6
0.9	09/02/2021	SEAB, NTUA, CIRCLE, VPF	Refinements on UML diagrams, Peer Review
1.0			Final version to be submitted

Quality Control		
Role	Who (Partner short name)	Approval Date
Deliverable leader	SEAB	12/02/2021
Quality manager	NTUA	12/02/2021
Project Coordinator	NTUA	12/02/2021

Table of Contents

Executive Summary.....	6
1. Introduction	7
1.1 Purpose of the document.....	7
1.2 Intended readership.....	7
1.3 Document Structure	7
2. MOSES concept and Innovations.....	8
3. Methodological approach	11
3.1 Terminology.....	11
3.2 Workflow	11
4. Identification of MOSES personas	13
5. MOSES scenarios	24
5.1 SC1: Scenario 1	25
5.2 SC2: Scenario 2	26
5.3 SC3: Scenario 3	26
5.4 SC4: Scenario 4	27
5.5 SC5: Scenario 5	27
5.6 SC6: Scenario 6	28
5.7 SC7: Scenario 7	29
5.8 SC8: Scenario 8	30
5.9 SC9: Scenario 9	31
5.10 SC10: Scenario 10	32
5.11 SC11: Scenario 11	34
5.12 SC12: Scenario 12	35
6. MOSES Use Cases	36
6.1 UCS1: Scenario 1 Use Cases (a & b).....	38
6.2 UCS2 Scenario 2 Use Cases (a & b).....	40
6.3 UCS3 Scenario 3 Use Case	42
6.4 UCS4 Scenario 4 Use Case	43
6.5 UCS5 Scenarios 5, 6, 7 and 8 Use Case.....	44
6.6 UCS6 Scenario 9 Use Case	49
6.7 UCS7 Scenarios 10,11 Use Case.....	50
6.8 UCS8 Scenario 12Use Case	54

7. Conclusions	56
References.....	57

List of Tables

Table 1 Benefits of the identified stakeholder groups from MOSES Innovations.....	13
Table 2 Matching of MOSES Personas with MOSES innovations	18
Table 3 Scenario Template	24
Table 4 Matching of MOSES Personas with the identified scenarios.....	24
Table 5 Use Cases associated with the corresponding scenarios	36
Table 6 Use Case Template	36
Table 7 UML Annotation	37

List of Figures

Figure 1 MOSES Concept & Innovations.....	9
Figure 2 MOSES Methodology for Use Cases and scenarios' development	12
Figure 3 An artist impression of the Robotic container handling system scenario.....	32
Figure 4 Process of Manoeuvring, Docking, Mooring and Undocking	33

List of Acronyms

Abbreviation / acronym	Description
3D	Three Dimensional
AI	Artificial Intelligence
BRM	Bridge Resource Management
CAPEX	CAPital EXpenditure
CO ₂	Carbon dioxide
CO _{2eq}	Carbon dioxide equivalent
ConOps	Concept of Operations
CRUD	Create, read, update and delete
DP	Dynamic Positioning
DSS	Deep Sea Shipping
Dx.y	Deliverable number y belonging to work package x
EMSA	European Maritime Safety Agency
HMSF	High Modulus Synthetic Fibre
ICT	Information and Communications Technology
ID	Identity Document
IMO	International Maritime Organisation
INEA	Innovation and Networks Executive Agency
IOSS	Intelligent Operator Support System
ML	Machine Learning
OPEX	OPERational Expenditure
RCH	Robotic Container Handling
SCC	Shore Control Centre
SCx	Scenario number x
SSS	Short Sea Shipping
TEN-T	Trans-European Transport Network
TEU	Twenty-foot Equivalent Unit
Tx.y	Task number y belonging to WP x
UCS	Use Cases
UML	Unified Modeling Language
VHF	Very High Frequency
VTS	Vessel Traffic Service
WPx	Work Package number x

Executive Summary

The present document is a deliverable of the MOSES project, which is funded by the European Commission's Innovation and Networks Executive Agency (INEA) under the Horizon 2020 research and innovation programme (H2020), reporting part of the outcomes of the activities carried out within the scope of work package (WP2). MOSES aims to significantly enhance the short-sea shipping (SSS) component of the European supply chain by addressing the vulnerabilities and strains related to the operation of large containerships, via introducing a constellation of innovations including innovative vessels and the optimisation of logistics operations. A two-fold strategy will be followed, in order to reduce the total time to berth for TEN-T Hub Ports and to stimulate the use of SSS feeder services to small ports that have limited or no infrastructure.

The current document is connected to Task 2.2 entitled: 'MOSES Use Cases and scenarios' under Work Package 2 entitled: 'From User Needs and Requirements to Specifications' of the MOSES project. The deliverable provides the description of MOSES personas, scenarios and Use Cases, which are related to MOSES innovations. The process analysis has considered and incorporated the outcomes of D2.1 'MOSES stakeholder and end-user needs', with the view to refine the initial set of user needs up to the required level of detail (via the Use Cases definition) and subsequently to provide a more detailed input to the MOSES technical (WP3-WP6) and demonstration (WP7) WPs.

The present deliverable has been developed towards adopting a persona centric methodology and by following an iterative approach of conducted interviews and workshops with external stakeholders, as well as by capitalising on the distinct knowledge and the diverse nature of MOSES consortium. The first step, in the process, was initiated by the identification of key MOSES personas, based on the MOSES innovations. This was followed by the identification of representative scenarios (based on the personas' needs and relations). The last step, in the process, was the Use Cases definition, which was initially supported by a dedicated workshop with external expert stakeholders and the members of MOSES Consortium. Use Cases description was based on the processes described within the scenarios and the interdependences between the innovations.

As a result, 13 personas have been identified, while 12 scenarios have been described and 8 Use Cases have been defined. The description of Use Cases from this document is not a static process, but instead, it will evolve during the project, based on the technical needs. In addition, the Use Cases will be used as a vantage point to make progress towards *Task 2.4 'Specifications for MOSES innovations'* and for the corresponding deliverable '*D2.4 Specifications and requirements for MOSES innovations*' for facilitating the Concept of Operations (ConOps) and the system specifications for the MOSES innovations.

1. Introduction

1.1 Purpose of the document

The purpose of the document is to describe the scenarios and the corresponding Use Cases for each of the MOSES innovations, as a stepping stone for the effective and efficient definition of the Concept of Operations (ConOps) and the system specifications for the MOSES innovations (T2.4).

The document has embraced the user-centric development approach employed in the MOSES project (as also detailed in D2.1) by developing the MOSES scenarios and their associated Use Cases towards adopting the persona-centric methodology and elaborating on the end-user needs as being described in D2.1. MOSES scenarios have been formulated in the form of narratives and the associated Use Cases have been systematically developed and documented using both tables and UML activity diagrams.

1.2 Intended readership

This deliverable is public and therefore addressed to the members of the MOSES Consortium, as well as to the stakeholders who are external to the MOSES project.

1.3 Document Structure

The document is structured in seven sections.

Section 1 introduces the purpose and scope of the document, as well as the intended readership.

Section 2 describes the MOSES overall concept towards briefly outlining the contribution of each of the MOSES innovations.

Section 3 outlines the overall approach used in this deliverable, both in terms of terminology and methodology used, in order to come up with the required scenarios and the corresponding Use Cases in relation to MOSES innovations.

Section 4 presents the process for the personas' identification, which will be the baseline for the MOSES scenarios creation.

Section 5 gives the description of MOSES scenarios, which are developed in relation to MOSES innovations.

Section 6 provides the corresponding to each scenario Use Case(s), by presenting a step-by-step description (both graphically represented via UML activity diagrams and structurally developed via tables) of how a persona, who actually uses a MOSES innovation will accomplish a goal.

Finally section 7, summarises the concluding remarks of the MOSES Use Cases and scenarios' analysis.

2. MOSES concept and Innovations

MOSES overall concept lies on its strategic vision to enhance the Short Sea Shipping (SSS) component of the European supply chain, by addressing the vulnerabilities and strains that relate to the concentration of the main container traffic in hub ports, via introducing a constellation of innovations including innovative vessels and the optimisation of logistic operations. MOSES aims to reduce the total time to berth for TEN-T Hub Ports and to stimulate the use of SSS feeder services in small ports that have limited or no infrastructure. To achieve its objectives, MOSES will implement a constellation of innovations, which are:

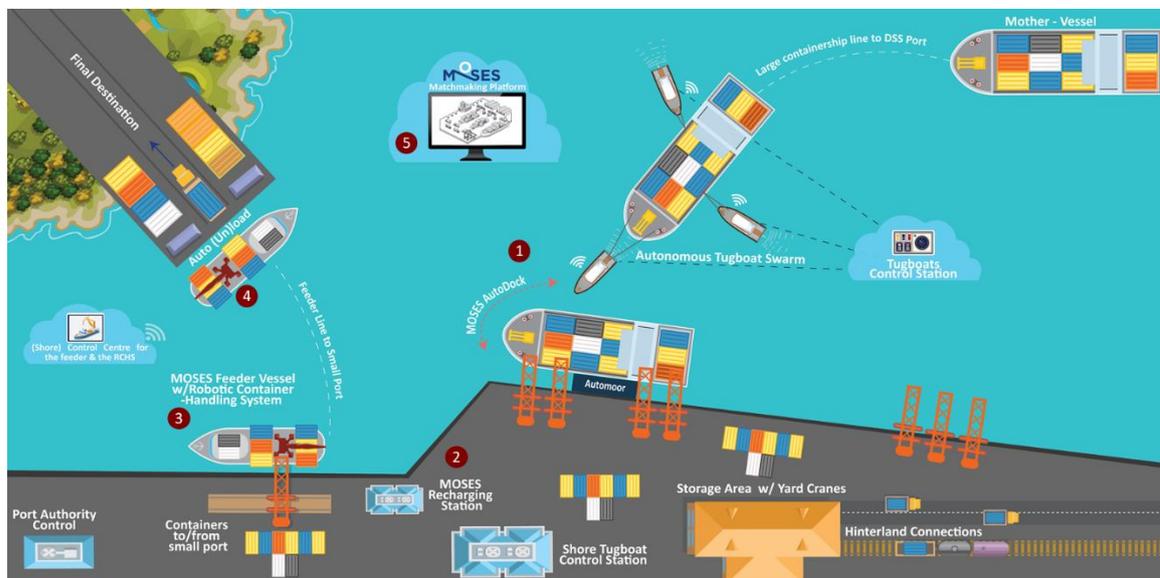
- **For the SSS leg:** an innovative, hybrid electric feeder vessel (**MOSES innovative feeder vessel**) that will prevail from different vessel concepts and will be designed to match dominant SSS business cases, increasing the utilisation rate of small ports. The MOSES feeder will be outfitted with a **self-sufficient robotic container-handling system** that will simplify the (off)loading of containerised cargo at Hub Ports and improve the operational capacity of small ports.
- **For DSS ports:** the adoption of an autonomous vessel maneuvering and docking scheme (**MOSES AutoDock**) that will provide operational independency from the availability of port services. This scheme will be based on the cooperation of (i) a **coordinated swarm of autonomous tugboats** with (ii) an **automated docking system (AutoMoor)** based on an existing product.
- A feasibility study for an automated shore-based power station (**MOSES recharging Station**), that will be fully integrated in the port energy management system, and it will be used for powering the MOSES innovative feeder and tugboats while berthed.
- A digital collaboration and matchmaking platform (**MOSES platform**) that aims to maximise and sustain SSS services in the container supply chain by matching demand and supply of cargo volumes by logistics stakeholders using Machine Learning (ML) and data driven-based analytics.

MOSES concept in form of a narrative is thoroughly described below (figure 1):

A large containership (mother-vessel) approaches a DSS port (or a large container terminal). Upon her arrival, she asks for assistance to safely moor at the dock. The assistance is provided by the **MOSES AutoDock**, a combined intelligent mega-system consisting of the **MOSES Autonomous tugboat swarm** for manoeuvring **and the MOSES adapted AutoMoor system**. The MOSES Autonomous tugboats are dispatched and assist the containership with the manoeuvring process in a swarm/cooperative formation. The MOSES autonomous tugboats are monitored through a remote-control station located in the DSS port (**MOSES Shore Tugboat Control Station**), which continuously monitors and gathers information about the process. The swarm of the tugboats automatically adapts its operation to the varying environmental conditions and the orders given by the Pilot of the large containership. As soon as the ship is on the right position at the dock,

the AutoMoor system, intelligently communicates and cooperates with the swarm of the autonomous tugboats in order the ship to be safely docked, considering also the prevailed operational conditions. The automated docking process is also monitored through the **MOSES Shore Tugboat Control Station**. Upon the safe docking, the AutoMoor system verifies ship's safe docking and informs the Tugboat Shore Control Station.

The containers' loading and offloading processes are ready to start. Containers may need to be moved to their destination via hinterland connections (trucks and/or rail) or to be shipped to destinations near small ports (in mainland or island). For the first case, containers are stored to a dedicated port area (Storage area), waiting to be moved via trucks and/or rail. For the second case, containers are stacked by existing port equipment near dedicated berths of the DSS port and then are loaded on the **MOSES Innovative Feeder Vessel**, which is equipped with the **MOSES Robotic Container-Handling System** that provides (semi¹-) autonomous (off)loading of the feeder.



MOSES Innovations:

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

Figure 1 MOSES Concept & Innovations

The Robotic Container-Handling System and the feeder are remotely monitored through a Shore Control Centre. The innovative feeder, while berthed at the DSS port, may use the **MOSES Recharging Station**, which is an automated shore-based power station. MOSES recharging station is also used for powering the tugboats. The laden MOSES Feeder proceeds with a reduced environmental footprint to the small port, which has no existing infrastructure to handle the containers' (off)loading process. As soon as the MOSES innovative Feeder vessel approaches the small port, where her docking is achieved without the need of tugboats, she automatically unloads the containers by using the Robotic Container-Handling System, either at the quay or directly on trucks. As

¹ The robotic crane will be an autonomous system concerning the (off)loading operations. Problems out of scope of the robotic crane (planning issues, object in the way etc.) will be handled by the operator.

a result, ports with minimal or no available infrastructure may be effectively integrated in the container supply chain. The MOSES innovative feeder vessel, then, continues her voyage to the next small port or she returns to the DSS port. The feeder could partly autonomously, operate, with the support of the Shore Control Centre, during the sailing leg of the voyage.

Even though the cargo has been successfully transported to its destination, the continuity and sustainability of the feeder service require the necessary adaptation of the existing port operations and the balance between demand and supply. To this end, the MOSES concept is supported by the **MOSES Matchmaking Platform** to handle effectively the changing of the freight flows, to increase the cost-effectiveness of partial cargo loads and to boost last-mile/just-in-time connections among the transport modes and backhaul traffic.

3. Methodological approach

3.1 Terminology

The Use Cases approach can support model-, narrative- and scenario-based requirement elicitation techniques. As they are being used within the context of several methodological approaches for capturing, modelling, and specifying the requirements of a system, the definitions of the most important terms, as they are being used within this document, are given below.

What are the ‘Personas’?

Personas [1] are fictional characters (represent a potential user), which are created based upon research data and the expert’s judgement, in order to represent the different user types. It can help us to recognise that different users have different needs goals and expectations, as it actually represents a group of users with similar characteristics.

What are the ‘Scenarios’?

Scenarios [2] are high-level informal narratives, describing Persona’s needs (context why the user would use MOSES), their interaction with MOSES innovations (tasks and how the user will accomplish the tasks), goals achieved and benefits. A scenario is a story about how an innovation may be used to improve existing processes or to achieve a task, without explicitly describing the use of innovative technologies/applications or software or other technological support to fulfil the task. A scenario is also more comprehensible by people, since it is described in the form of a coherent narrative story, and consequently it is easier to follow.

What are the ‘Use Cases’?

A Use Case [3] *‘is all the ways of using a system to achieve a particular goal for a particular user. Taken together the set of all the Use Cases gives you all of the useful ways to use the system and illustrates the value that it will provide’*. It is a step-by-step description of how a person/an autonomous system as actor, who uses/follows a process or system will accomplish a goal. The use-case approach has a much broader scope than just requirements’ capture, and they are used to drive the development. Use Cases focus on functional/operational requirements and capture interaction. Because they focus on the interaction between a user and the systems, they are referring to details about what the user needs to see, to know about, or to react to.

3.2 Workflow

To maximise market potential and applicability of MOSES products and services, a stakeholder driven approach through implementing a co-design and persona centric methodology [4] has been adopted, for the formulation of MOSES scenarios and Use

Cases (figure 2). The methodology models a system with the involved stakeholders and their interactions in terms of service functions.

In the context of this process, stakeholders were identified (T2.1) and involved in the beginning of the development process. Co-designing of products and services means involving stakeholders fully in the process through a dialog. In this case, stakeholders are partnering in the process of developing products and services: a) They provide the information through dialogue; b) They participate in the solution design; c) They participate in solution development; d) They design the experience as they interact with it (proactive).

The whole process was initiated internally within the consortium, with the support of pilot partners, towards the identification of MOSES stakeholders (T2.1). In what followed, dedicated analysis and interviews (semi-structured and unstructured) with relevant organisations took place during two online workshops. The aim was to define business/operational profiles-the MOSES personas-and the area(s) of intervention and interaction with MOSES innovations.

Moreover, two online workshops in the project's pilot areas were organised involving the participation of external stakeholders, towards the collection of information on the stakeholders' practices, challenges and perception of MOSES concept and innovations. The latter was supported also by the launch of an online survey/questionnaire, aimed at collecting comprehensive feedback from broader range of MOSES related stakeholders. During the workshops, a first iteration of the MOSES scenarios took place. User scenarios are high-level narratives describing: i) persona's needs (context why the user would use the MOSES innovations), ii) goals and benefits. Further to this, an offline iteration for enhancing, refining, and consolidating the co-designed scenarios was realised.

The final step included the definition of Use Cases based on the identified scenarios. Use Cases constitute more detailed and comprehensive descriptions of the scenarios for each of the MOSES innovations. They provide a step-by-step description of how a persona who uses one of the MOSES innovations will accomplish/fulfil a goal/need. They will be listed both unified table templates and will be graphically represented using UML activity diagrams.

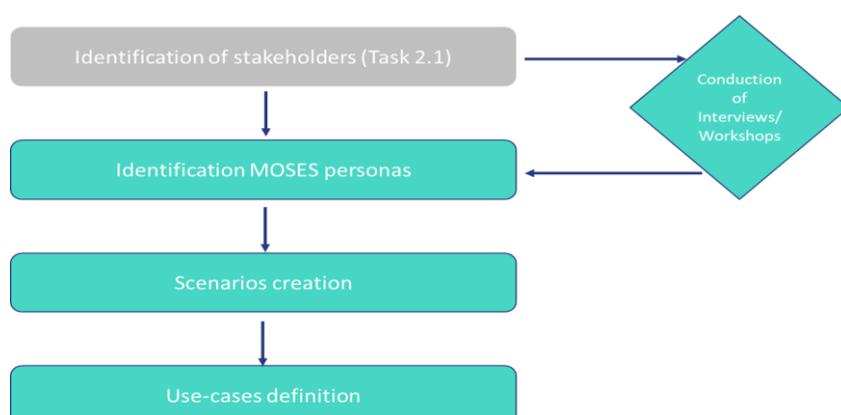


Figure 2 MOSES Methodology for Use Cases and scenarios' development

4. Identification of MOSES personas

MOSES will address the needs of different stakeholders being involved with the Short Sea Shipping component of the European container supply chain covering both the logistics and maritime domain. The following table (table 1) provides an overview of the main stakeholder groups (as identified in deliverable *D2.1 'MOSES stakeholder and end-users needs'*), which are categorised in primary and secondary groups [5]. However, in D2.1 the intention was to describe the stakeholder groups' individual points of interest for the MOSES project in general, while in the current document the aim is to describe the main benefits arising from the foreseen MOSES innovations per stakeholder group, in order to facilitate the personas identification process.

Table 1 Benefits of the identified stakeholder groups from MOSES Innovations

Stakeholder Group		Benefits from MOSES Innovations/services
Primary stakeholder groups	Port Authorities	<p>Port authorities and Terminal Operators will benefit from MOSES AutoDock system, as the automated tugboats will reduce the waiting times and will disunite berthing from any disruptions and the adapted AutoMoor System will guarantee a significant reduction in docking times. Moreover, there will be the economic benefits due to the automation, and reduction of man power in operations. It is expected the AutoDock system significantly increases the safety during mooring operation while facilitating the (un)load of the cargo by reducing the ship movements. In addition, and more precisely small ports with minimal container handling infrastructure will benefit from MOSES feeder with its on board (semi-) autonomous robotic container handling system, as it gives complete independence from the port infrastructure. Thus, small ports do not need to rely on costly gantry cranes, while they can efficiently exploit their capacity. In addition, MOSES Innovative feeder offers a more energy efficient mode, due to its hybrid electric powering towards reducing the SSS supply chain environmental footprint, which is also supported by the MOSES feasibility study for an automated shore-based power station for powering the MOSES feeder. Automated shore-based power station has a significant reduction in time of connections of port electrical facilities to ships, therefore, motivates the shipping lines towards using the shore-based stations, in particular for container vessels with the lowest port stay times.</p>
	(Container) Terminal Operators	

Ship Owners	<p>Ship Owners/Operators as well as Tugboat owners/operators will benefit from MOSES AutoDock System as it is going to automate the waterborne operations in DSS ports. More in detail, MOSES AutoDock System, which is composed of an autonomous tugboat swarm and Trelleborg's AutoMooring system, is going to provide an automated, safe and efficient navigation within port area by safely maneuvering and docking a large floating vessel in an automated way. The automated process adoption is expected to have a positive impact in the minimisation of delays, in the reduction of relating costs and in the decrease of human error related accidents. Consequently, it also reduces the air pollution emissions from ships in port areas. In addition, ship owners can be benefited for the MOSES feeder, as it introduces a new conceptual vessel design, which is tackling key operational (hydrodynamic and energy) characteristics, towards serving sustainability and autonomy requirements. Last but not least, ship operators will also benefit from autonomous container handling system as it will help operators' cargo planner on stowage plan creation from container handling [loading/offloading] sequence point of view.</p>
Ship Operators	
Tugboat Owners	
Tugboat Operators	
Maritime Shipping Companies/Shippers	<p>MOSES matchmaking platform will be a key tool for horizontal shippers', liner agents', freight forwarders' and carries' collaboration [6] as it is expected to face uprising demands and at the same time to balance backhaul traffic. The platform will also serve as a useful tool for logistics stakeholders within the entire supply chain for the consolidation and matching of cargo flows in both directions, booking/trading containers with shippers/ freight forwarders, communicating freight cost with shippers, arranging/ tracking container movements. In addition, truck drivers in transport/logistic companies for container to/from quay side will also be benefitting from the autonomous container handling system as they will get notifications in advance about container availability status for transportation.</p>
Transport Operators/ Logistic Companies/ Freight forwarders/Liner agents/Brokers	
Information (ICT) and Communication Technology Systems Providers	

		<p>Optimization, Warehouse Control Systems, etc. All MOSES innovations require advanced information and communication protocols to ensure safe and secure operation, given the high levels of automation technologies that are being developed and implemented within. Companies in this domain are interested in the development and maintenance of the relevant software and hardware modules for commercial purposes and for advancing their current portfolio. For instance, the inter-communication of the automated tugboats as well as the tugboat communication with the port require reliable communication pathways to perform efficiently.</p>
	<p>Academia/ Universities & Research Centres</p>	<p>All MOSES innovations can set the ground for fostering the research activities in the maritime supply chain logistics domain and create cross fertilisation with them. This group can empower the proliferation of knowledge towards achieving a cleaner, safer, automated, and smarter ships and sustainable use of the maritime environment through the development of specific tools, algorithms, analyses and processes.</p>
<p>Secondary Stakeholder Groups</p>	<p>Shipyards</p>	<p>The vessel automation schemes introduced in the context of MOSES can be of benefit to relevant stakeholders being involved in the shipbuilding process (i.e., shipyards) allowing the latter to explore operational and technological concepts and innovations in this field. The concept of the autonomous feeder also provides a high-tech product that improves the competitiveness of European shipyards in front of the third countries competitors and can also take advantage of this output to lead in the areas of automation worldwide.</p>
	<p>Electric propulsion systems' manufactures</p>	<p>MOSES innovations are oriented towards electric/hybrid propulsion systems. In specific, the Autonomous Tugboats and the Innovative Feeder Vessel rely on electric propulsion by design. Manufacturers of such propulsive systems can benefit from the increased demand by the shipping industry. In turn, these manufacturers can adapt to the needs of newly developed, innovative technologies to expand their expertise and portfolio with new products and services that are close to the industry needs.</p>
	<p>Small port adjacent economy / port city society</p>	<p>Small port adjacent economies are heavily depended on the infrastructure and capabilities of the adjacent port. The innovative feeder vessel and the robotic container</p>

		<p>handling system can greatly support small ports that lack the infrastructure to support container handling, subsequently improving the local logistic-related businesses and also increasing local commercial traffic and promoting local industry to export at a more competitive logistical cost. In addition, port city society will face indirect advantages from the use of MOSES innovation, especially in terms of environmental impact. For example, MOSES Matchmaking platform’s objective is to balance traffic against oversaturated routes which goes hand in hand with excessive production of CO₂. Automation in cargo handling processing and optimisation in capacity utilisation in ports will have a positive cascade effect to the adjacent city. The raised benefits can be summarised to less noisy environment, less congestion, less air pollution emission, and also favoring opportunities for skilled labor force and attractive port city for investments in logistic hubs, training, other markets.</p>
	<p>Classification Societies and Maritime Administrations</p>	<p>Maritime classification societies play a very important role in the safety of the product, since to a certain extent they are responsible for certifying that the feeder, tugboats and the RCH are in a condition to operate safely. The maritime administration (Harbor Master), together with the Port Authority, is responsible for ensuring that maritime operations within the port are carried out in a safe manner. The MOSES innovations infer a breakthrough concept in the port operations, particularly in the maneuvering (MOSES AutoDock), which need carefully addressed from the safety point of view and in accordance with the existing regulatory framework [7,8,9].</p>
	<p>Marine/Port equipment suppliers</p>	<p>Port equipment manufacturers refer to the variety of companies that supply different products to ports. Recently automation of port operations has gained a significant attraction. One of them is the Autonomous Tugboats that rely on advanced communication systems to perform their duties as expected, equipment manufacturers are interested in meeting this demand. In addition, the AutoMooring system requires new infrastructure to be installed in ports. With these Auto Docking demand at the focus of attentions, marine/port equipment suppliers will be also able to increase their</p>

		competence on building more connected and intelligent subsystems.
	Regulatory and Standardisation Bodies	Autonomous shipping and Automation of port operations are under crucial discussion and analyses at international level by IMO, and European level by EMSA in order to set the regulations/guidelines that meets all safe technical and also regulatory aspects. Regulatory and Standardisation Bodies belong to the wider environment of MOSES stakeholder, being interested in all MOSES innovations. The highly automated systems incorporated in MOSES offer a new insight on maritime transport automation, revealing unexplored areas that may need to be accounted for in future set standards and regulations.
	Coast guards	Coast Guard is of paramount importance since they are familiar with the technical layout and the behaviour of all operating vessels in order to perform their duties. Therefore, Coast Guards are interested in the Innovative Feeder Vessels and the Autonomous Tugboats where the highly automated systems may challenge their existing services and skills.

The abovementioned stakeholders' groups and their correlation with the main benefits arising from the foreseen MOSES innovations were used as a stepping stone during the personas' identification process. As stakeholder groups tend to be large audiences with a multidisciplinary group of persons in different working positions with different challenges and responsibilities, their correlation with the potential MOSES innovations' benefits, proved to be a critical and important process towards properly identifying the key personas in the right positions.

A persona is essentially an archetype or character that represents a potential user of application and it is based on user information collected from multiple users through observations, interviews, surveys, etc. However, the persona is presented as a description of an individual person, even though the persona actually represents a group of users with similar characteristics. To be more specific, they are formed using characteristics of people who present similar goals, motivations and behaviours. A persona summarises the target user's background, goals, and needs related to the application, the innovation, the service and/or product. They have a supportive role in order to describe and highlight differences between goals and behaviours [10].

The persona helps to better understand target users by enhancing realism and increasing engagement in a design team with end user representations [11], so developers can design a solution to meet their expectations. A persona is considered as a surrogate for real users, as it identifies the aspirations and expectations, driving their behaviour and

attitude in a way that is easy to relate to. This knowledge is essential to ensure that, in our case, MOSES, innovations are designed by having the end users in top priority during the pre-design process.

For the purpose of defining MOSES scenarios and Use Cases, 13 different personas were identified (table 2) based on the one hand on their business/operational profiles and considering their fundamental interaction with MOSES innovations, and on the other hand on the research as well as on the information and knowledge collected during the project's co-design activities (workshops).

However, even though most of personas have been identified as a need for the scenarios' creation, in some scenarios, new/future personas (presented with an * in table 2) were introduced during the scenario' development process, as an emerging need for the innovations that are mainly dealing with an autonomy operational aspect, in order to guarantee their future, effective and efficient way of operation.

Table 2 Matching of MOSES Personas with MOSES innovations

Personas		MOSES Innovations					
		MOSES AutoDock		MOSES Innovative Feeder Vessel	MOSES Robotic Container-Handling System	MOSES Recharging Station	MOSES Matchmaking Platform
		MOSES Autonomous tugboat swarm	AutoMoor				
1	Port management staff					X	
2	Shipper						X
3	Carrier						X
4	Freight Forwarder						X
5	Moorer		X				
6	Pilot	X	X				
7	Tugboat Captain	X	X				
8	Shore Tugboat Control Station operator *	X	X				
9	Shore Control Centre operator for Robotic Container Handling System*				X		
10	Terminal operator				X		
11	Bridge crew member			X			

12	Shore Control Centre Operator for the feeder*			X			
13	Shipping Line executive manager			X			

Each of the above identified personas are further analysed below, by further elaborating on their main role and activities, as well as on the challenges they regularly face.

Persona 1: Julio, member of the Port management staff



Main role and activities: Julio’s daily duties play a vital role in the efficient use of the port facilities and resources, and takes charge of the general technical activities within port, such as the development of defined efficient procedures for the port’s technical processes and operations.

Challenges: The decarbonisation of shipping is one of the key items in the ports’ agendas. As a matter of fact, the required technological innovation constitutes a major challenge for port sector. Ports need to strive towards the development of new innovative, more environmentally friendly, and efficient solutions.

Persona 2: Fotis, the Shipper



Main role and activities: Fotis is a person who takes charge of the efficient transportation of goods and commodities, dealing also with all the necessary administrative procedures to complete the transportation and ensure that no complications arise during the cargo-sending process. Fotis is mainly responsible for transport booking, cargo packing and communication with forwarded or directly with carrier.

Challenges: One of the main challenges that Fotis faces is that he is (usually) not aware of the different shipping options that are available to them. This includes also the selection of the most suitable shipping rates and transit times that can be a very time-consuming process (i.e., via searching for and comparing services). Moreover, cases of shipping demand exceeding forecast (i.e., shortage on containers for bulk shipping) can result to delays, additional costs and potential penalties.

Persona 3: Ian, the Carrier



Main role and activities: Ian is an individual that is legally authorised and is responsible for the transportation of cargo from one place to another using different modes of transport systems (e.g. feeder vessels, rail, trucks, road transportation etc.). In the shipping domain, cargo is moved by water.

Challenges: Ian needs to be able to optimise the operations towards the provision of on-time transportation services while meeting market demand. Uncertainties with respect to competition and market demand can result to additional costs in purchasing and maintaining the needed equipment for their activities (i.e., vehicles, warehouses, etc.).

Persona 4: Elena, the freight forwarder



Main role and activities: Elena is a person that streamlines the shipments either for individuals or corporations in order to transport goods from the manufacturer or producer to final destination point (acting as a third party for shipper interests). Elena does not move the goods, but she is in contract with a carrier or often multiple carriers to move the goods. Elena, as freight forwarder acts as expert in the logistics network.

Challenges: Elena aims at lowering costs and facilitating the logistics of transportation. Thus, it is important for her to ensure that her business' partners share with her accurate and timely information in order she can provide her customers with competitive services.

Persona 5: Francisco, the Moorer



Main role and activities: The main role of Francisco is to undertake the ship mooring process, from the port's sides, by handling the ship's mooring lines (being tied up using ropes), when leaving and arriving at the mooring.

Challenges: Francisco believes that even though there have been advances in mooring technology, such as the introduction of High Modulus Synthetic Fibre (HMSF) ropes, mooring operations are considered some of the most complex and dangerous tasks on ships. Mooring operations are -in most cases- a routine, but when things go wrong, their cascading effects can cause very damaging and sometimes tragic circumstances [12].

Persona 6: Nikos, the Pilot



Main role and activities: Nikos is an experienced Pilot/a professionally licensed mariner, whose role is to board and assume the conduct of a vessel and guide it along the safest route to its port of call. He is an expert on the regulations and the specific environment of the pilotage area in which he is licensed.

Challenges: Nikos is experiencing a relatively high workload and his role is equally important as that of a Captain. He is responsible for evaluating the environmental conditions, the port readiness and the tug availability. The greatest challenge is to effectively communicate with the tugboat(s) Captain(s), in order to ensure that the ship will be smoothly and safely navigated into/from port and safe berthing/unberthing is achieved.

Persona 7: John, the Tugboat Captain



Main role and activities: John is the person who communicates with other vessels and ensures the smooth conduction of the operations during berth. His is also responsible for steering the tugboat in order to push or pull vessels to destination and to berth or unberth containerships.

Challenges: The role of John is a high-challenging role as the safety of all on-board personnel has to be ensured and the vessel's technical/mechanical systems have to be under control. Also, the navigation during berth constitutes a great challenge as every decision taken, depends sometimes on the unpredictable weather conditions, on traffic in the port area, etc.

Persona 8: Paul, the Shore Tugboat Control Station operator



Main role and activities: Paul, the Shore Tugboat Control Station operator is responsible for supervising the autonomous tugboats swarm operation and the mooring/unmooring process performed by the mooring units (towing and berthing process of a mother vessel).

Challenges: The Shore Tugboat Control Station operator is expected to supervise several towing and mooring/ unmooring processes at the same time. The challenge is to be able to switch between operations when required and regarding the tugboats swarm to be also able to switch rapidly from manual operation to automatic and vice versa. Furthermore, another challenge he faces is the communication coordination between the various involved people (i.e., tugboats Captain(s), the Pilot of the mother vessel, the Moorer, the port authority personnel, etc.) in both usual and emergency situations.

Persona 9: Otto, the Shore Control Centre operator for the RCH



Main role and activities: Otto is responsible for supervising the safe and efficient loading and offloading of containers by robotic cranes on multiple ships.

Challenges: Otto is expected to supervise several offloading and loading operations. The challenge is to be able to switch between operations when required by the local circumstances, like a safety issue because people are detected on the quay. The Intelligent Operator Support System (IOSS) software assists the operator in building appropriate situation awareness and informing the operator on possible issues that might rise.

Persona 10: Tessa, the terminal operator



Main role and activities: Tessa is responsible for the safe and efficient loading and offloading of the correct containers to and from the terminal, i.e., to the quay of a SSS-port.

Challenges: The challenge for Tessa is to make sure that the conditions for the loading and offloading area are optimal and that it can commence in a safe way. If problems do occur, she needs to interact with Otto in order to find a way to solve the problem. For this line of communication, a device is needed in order to communicate on basis of a shared understanding of the situation.

Persona 11: Hans, the Bridge crew member



Main role and activities: The Bridge crew member, Hans, belongs to the Bridge team and has an important role in the well-functional Bridge Resource Management (BRM). The main activities of the Bridge crew member include the Bridge navigational duties and the maintenance of communications and interactions with the port and other operating areas of the ship. In addition, he is also involved in the loading and offloading operations, as well as in assisting the ship master in risk assessment of ship key operations that may have an impact on important decisions.

Challenges: Constant and effective communication is one of the critical challenges for the Bridge team, as the effective and accurate transfer of information is a complex process. Teamwork within the Bridge team (between tallyman, hatch clerk and the Captain) plays a crucial role in ensuring safe navigation as well as effective loading and offloading cargo operations.

Persona 12: Nixie, the Shore Control Centre Operator for the feeder



Main role and activities: Nixie, the Shore Control Centre Operator is a person who is responsible for supervising the safe and efficient sailing and manoeuvring of several container feeder vessels during the autonomous operation of these vessels.

Challenges: The SCC operator is expected to monitor and control the sailing operations of the vessel in open water and the sailing areas as agreed with the crew on board of the container feeder vessels. The challenge is to coordinate the sailing of the vessel in such a way that the crew on board does not have to assist or check this operation. When the situation requires, the operator will have to communicate with the Bridge crew how the operation is to be coordinated given the possible local issues that can arise.

Persona 13: Gerco, the executive manager in a Container Shipping Company (Shipping Line)



Main role and activities: The executive manager of the containers shipping company, Gerco, his main role is to support strategic decisions relating to the feeder lines that the company maintains, which include deciding what kind of vessel will serve the lines most cost-effectively.

Challenges: The challenges he faces are related to strategic decisions based on the available cargo demand, the minimisation of delivery times, the compliance with the increasingly stricter environmental regulatory framework, and the delivery of cargo to ports with limited or no infrastructure.

5. MOSES scenarios

Taking into consideration the user needs and requirements, as well as the identified personas, MOSES scenarios are compiled, consisting of high-level narratives that describe the needs of MOSES personas as well as the way of interacting with MOSES innovations so as to achieve their goals. The gist of the idea behind personas and scenarios is that they help us to focus on the intended user of the tools and services. Scenarios may include references to more than one persona, to showcase the required interdependencies between both the innovations' operations and personas' responsibilities. Scenarios aim to help designers understand what motivates users when they interact with a design – a useful consideration for ideation and usability testing [13].

Scenarios focus on describing particular instances of use and on a prospective user's view of what should happen. Scenarios have been formulated based on the following template (table 3), where the heading includes the scenario number as well as a unique identifier (for facilitating the reference of each scenario in the Use Case section, as well as in other upcoming related deliverables) and the table body includes the description of the problem and the need of the persona(s) in each narrative.

Table 3 Scenario Template

Scenario xx (SC xx) for <Name of associated MOSES innovation>	
- What is the problem of the persona?	
- What is the need of the persona(a)? (It should be provided in the form of a user story/narrative).	

For the needs of MOSES, 12 scenarios have been identified. In the following table 4, an attempt to briefly showcase which scenario corresponds to each innovation and who is the persona(s) involved, is made.

Table 4 Matching of MOSES Personas with the identified scenarios

Personas		MOSES Innovations					
		MOSES AutoDock		MOSES Innovative Feeder Vessel	MOSES Robotic Container Handling System	MOSES Recharging Station	MOSES Matchmaking Platform
		MOSES Autonomous tugboat swarm	AutoMoor				
1	Port management staff					SC1	
2	Shipper						SC2
3	Carrier						SC3
4	Freight forwarder						SC4

5	Moorer		SC5				
6	Pilot	SC6	SC6				
7	Tugboat Captain	SC7	SC7				
8	Shore Tugboat Control Station operator *	SC8	SC8				
9	Shore Control Centre operator for RCH*				SC9		
10	Terminal operator				SC9		
11	Bridge crew member			SC10			
12	Shore Control Centre Operator for the feeder*			SC11			
13	Shipping Line executive manager			SC12			

Each of the above 13 referenced scenarios are detailed described below:

5.1 SC1: Scenario 1

Scenario 1 (SC1) for the MOSES recharging station

Julio is part of the management staff of the port of Valencia. During the last years, the pressure to reduce the environmental impacts of the port operations has increased. The ports are very close to the cities and the air pollution emissions coming from the funnel of the ships causes a certain alarm to both citizens and port workers. Julio knows very well that connecting the ships to the electrical grid would reduce notably the environmental impact (58% of the CO_{2eq} emissions come to the atmosphere from the port activity).

On the other hand, hybrid ships are starting to become a reality. One example is the MN ECO VALENCIA, a last generation ro-ro owned by the Grimaldi shipping company, which has a hybrid propulsion installed.

Julio needs to provide the recharging battery services at a price that must be competitive with diesel/fuels burned by generators onboard the berthed ships.

Controlling the operational costs of implementing hybrid technology and making them competitive with fossil fuels will significantly contribute to improve air quality in the port environment and the urban area in the port vicinity.

Julio needs to evaluate the battery recharging technologies available in the market, assess the introduction of innovations and calculate the cost of providing the service.

For the battery recharging service to succeed in the market, it is crucial that it does not interfere with port operations. Therefore, Julio needs that the battery recharging station does not interfere with the movement of the cranes, it adapts to the changes in the tides, etc.

Finally, Julio will have to develop the procedures for the recharging station to operate safely in the scope of the port operations that normally take place in the port. For example, it will be necessary to assess whether the loading of the vessel should be stopped when loading or offloading dangerous goods, or whether it should be done at a certain distance from the socket that is connected to the ship.

5.2 SC2: Scenario 2

Scenario 2 (SC2) for the MOSES Matchmaking Platform, on behalf of the Shipper

Fotis is a supply chain manager/shipper. His daily duties lie on the appropriate packaging and tagging of goods and cargo. He is also responsible for dealing with all documents required for the transportation procedure, so that no complications arise during the cargo-sending process. He is currently dealing with the transportation of chemicals and other dangerous goods and he is in constant communication with the shipping companies, customer service, and vendors to monitor the status of shipped products. His problem is that the transportation of such specialised/sensitive cargo requires the assessment of optimal routing, in order to manage the overall risk of the transportation (according to Risk management framework for inland transport of dangerous goods [14]).

For providing the best service to his clients, Fotis needs a system to extract the information related to a selection of an available optimal service provider/route (and possible alternatives) based on the type of freight/cargo as well as the respective cost per route. He, also, needs to know about the timeframe of the cargo delivery based on the different transport modes.

5.3 SC3: Scenario 3

Scenario 3 (SC3) for the MOSES Matchmaking Platform, on behalf of the Carrier

Ian is a cargo flow coordinator at a shipping line (carrier). His daily duties correspond to the consolidation, analysis and adjustment of the flow of full and empty containers, in order to optimise vessel loading and to meet the clearly defined schedules in an effective (both timely and environmentally) and efficient way. The challenge Ian faces is the imbalance of product supply and demand, and thus the imbalance in the container flow by taking also into consideration the dynamic environment that occurs in the transportation operations. As a result, empty containers accumulate at demand centres, which must be efficiently repositioned to ensure the continuity of shipping activities [15]. Ian needs a system that can meet the time-dependent demand, supply, and capacity requirements, in order to minimise the logistics (storage) and distribution (transportation) costs. He wants to be able to report, in real time, the available capacity

of a vessel(s) (both in container size and volume of a cargo) and also, the available possibilities for Just-in-time deliveries, along with the associated costs. By being capable of making this information available to both shippers and liner agents/freight forwarders, he can contribute to the decrease of empty container movements which can also result to decrease in fuel consumption and thus have an environmental and sustainability effect on the society [16].

5.4 SC4: Scenario 4

Scenario 4 (SC4) for the MOSES Matchmaking Platform, on behalf of the freight forwarder

Elena is the operations manager of a freight forwarding company. She deals on a daily basis with a large number of receiving orders that need to be transported to their final destinations. She needs to search for each order, the most efficient way (both timely and financially) for the transportation of the freight, in order to provide competitive offers to the customers. Her problem is that the whole process takes too much time and the cargo volume orders (in most cases) cannot be streamlined within the same day. As a result, the fluctuations in the exchange rates of the currencies of the countries, influence the prices for the freight forwarding services.

Elena needs a visual and time-efficient way to extract the information related to a selection of a logistic route (including the available modes of transportation along the suggested corridors) based on the available type of volume and weight, the destination, the required time (arrival and departure timeframe) and the associated cost for the transportation (which will be provided by Ian, the Carrier).

5.5 SC5: Scenario 5

Scenario 5 (SC5) for the AutoMoor system

Francisco is a Moorer working at a DSS port (e.g., Piraeus, Valencia). His daily duties are to collect the mooring lines of a ship, to carry them and to fix them to the mooring device such as a bollard on the quay. The specific fixing points and the order of attachment are based on instructions given from the Captain of the ship and/or the Pilot.

Francisco is concerned about the risks to his health and safety that this activity entails. Statistics from the European Harbour Masters' Committee show that 95 percent of personal injury incidents are caused by ropes and wires, and 60 percent of these injuries happen during mooring operations.

In addition, the increasing size of the ships and the increasing demand of DSS ports to serve time-efficiently multiple containerships, have made the mooring and unmooring ship operations more complicated.

The re-engineered AutoMoor system, which will be developed in MOSES, will introduce a new operational method for ship mooring and unmooring operations.

As the system does not use ropes, Francisco will not be in danger of suffering an occupational accident that may result in serious injury or death. Francisco will be now supervising the automatic process on-site.

5.6 SC6: Scenario 6

Scenario 6 (SC6) for the MOSES AutoDock system, on behalf of the Pilot

Nikos is an experienced maritime Pilot, working in the port of Piraeus (or port of Valencia) for more than 10 years. He is boarding and assuming the command of vessels for guiding them along the safest route to the port, on a daily basis. Nikos is responsible for evaluating the environmental conditions, the port readiness and the berth availability in order to ensure that the ship will always be safely navigated to/from port and successfully berthed/unberthed. After receiving a Pilot request, Nikos sets the piloted vessel requirements (side to put vessel – ladder position, course degree, speed) and then he goes on board, where his first actions are to be installed in command, establish effective Bridge team collaboration, and develop an effective communication with the port, the tugboats and the Vessel Traffic Service (VTS). Now that he has assumed command, Nikos is ready to make an evaluation of the environmental conditions and decide which is the best course of action, having taken all the appropriate precautions, including closed-loop communication with Captain and crew and mutual understanding. Then, while smoothly navigating the containership to the port, Nikos, in cooperation with the Captain of the vessel, decide the required number of tugboats, Nikos commands and coordinates them to proceed to the berthing operation and finalise it.

A typical day at work means a high workload for Nikos, having to play a role of similar importance to that of a Captain, while at the same time he is the main person who communicates with all parties. A group of two, three or sometimes four tugboats is usually needed to be coordinated in order to safely berth a containership and Nikos is responsible for guiding the tugboats' Captains during the operation. Moreover, he needs to constantly communicate with the Bridge team and the mooring crew, being responsible for orchestrating the whole operation by taking into consideration any special remarks regarding the vessel and any changes in the port environment (traffic, weather conditions, unexpected incidents). The final destination of the navigation into the port is to berth the vessel at the quay. Once the vessel is in place, the mooring of the vessel can commence. While the mooring operations are underway the vessel must still be held in place securely. Mooring operations are a manual process that can have varying time requirements especially as the size of vessels, particularly the container vessels, continues to increase. Until the vessel is safely moored the tugboats and Pilot are unable to proceed with the next vessel that requires navigation assistance.

In all the above tasks that need to be accomplished, many risks and safety issues may occur, with human errors and miscommunication being the most usual [17]. Therefore, the Pilot's greatest challenge is the effective communication between all parties and traditionally such actions are organised verbally over VHF and maintained in working memory, producing an important shared context between the Bridge team and the

tugboat(s) involved in port manoeuvres. Thus, to reduce the risk of miscommunication and focus more on the safe navigation, Nikos would like to provide higher level or more goal-based commands, but in that case such information will not be provided to a specific tugboat.

The introduction of a swarm of autonomous tugboats will enrich the towing and berthing process. As mentioned in the Section 2, the remote-control station for the tugboats continuously monitors and gathers information about the process. The Pilot provides now high-level goals when needed in each phase of the towing/berthing (e.g., reduce speed by 2 knots, change the course by 5 deg). This information is transferred also to the remote-control station providing the input for the automatic adaptation of the swarm operation to satisfy the required maneuver and ship route. The Pilot monitors the effect of the swarm operation and notifies when deviations exist. Furthermore, the MOSES AutoMoor system will eliminate the time required for the manual mooring of the ship, allowing the Pilot and the tugboats to move on to the next vessel earlier, as well as, facilitating the use of time previously spent on mooring the vessel now on loading and offloading the containers. The increase in effective operational time while the vessel is at berth provides significant economic incentive for the use of an AutoDock system.

There is evidence that as ship sizes increase (thus reducing visibility of the tugs), and as there is greater complexity in modern ports, this part of the port operations could benefit from being actualised in some form of shared visual representation. The remote-control station, by continuously obtaining data related with the status of the tugboats, the mother vessel, and the environmental conditions, could be a source of shared information. Therefore, the system of autonomous tugboats swarm and a remote-control station could absorb the communications workload and great part of the tugboats operation.

In such a case, Nikos can focus on his work to safely navigate and berth the mother vessel, eliminating the complexity of communicating with all the parties at the same time and leaving an important part of the coordination to the control station. Additionally, Nikos constitutes a back-up safety measure taking on-board command when an incident happens.

5.7 SC7: Scenario 7

Scenario 7 (SC7) for MOSES AutoDock system, on behalf of the tugboat captain

John is an experienced Tugboat Captain, having worked in all major Greek Ports and participated in operations all over the Mediterranean Sea. Currently, he is a master of a tugboat, with its main duties in a large container terminal. He is responsible for the control of the tugboat in order to perform push or pull operations in order to berth or unberth containerships. John has a highly challenging role as the operations need to be conducted in a safe manner and, usually, under unpredictable weather conditions and in the presence of other hazards (e.g., dense traffic within the port).

The most crucial of John's duties is the effective communication with the Pilot who coordinates the whole operation. There is also a brief communication with the other

tugboat(s) Captain(s), but it is of less importance compared to the one between John and the Pilot, which is the key to the whole towing/berthing operation. This communication is continuous and dynamic, being organised verbally over VHF and maintained in working memory, producing an important shared context between the Bridge team and the tugboat(s) involved in port manoeuvres.

The introduction of the MOSES AutoDock system, consisting of the tugboats autonomous swarm and the AutoMoor system, will automate the process of the control of the tugboat in terms of steering and propulsion control during the towing/berthing and will automate the mooring/ unmooring process. These functions will be carried out automatically considering the operation of the tugboats as a swarm to satisfy the needs (as set by the Pilot/Nikos) for the towing / berthing process of the vessel.

In such a case, John should remain on board the tugboat and supervise the procedures, without reducing his situation awareness, as he would be the one to intervene or inform the Shore Tugboat Control Station when an emergency or a malfunction during the operation occurs. His role should be supported by a continuous monitoring and decision-support system aiming at the status of the tugboat (machinery, propulsion and hull), enabling him to immediate respond for safety reason(s) either by informing and warning the remote-control station or by asking for permission to take control. The latter would serve as the last resort, as the control station will have the capability of obtaining the control of the tugs at any time.

John will benefit in terms of working stress and elimination of human errors during navigation or miscommunication, as a big load of communications would be transferred to the control station. John's role on the navigation leg of the tugboat operation (e.g. approaching the vessel from the tugboat station and return after completion of the task) remains.

5.8 SC8: Scenario 8

Scenario 8 (SC8) for the MOSES AutoDock system, on behalf of the Shore Tugboat Control Station operator

Paul is an experienced operator at a remote-control station, working in the port of Piraeus (or Valencia). Paul oversees the autonomous tugboats swarm operation (towing/berthing process of a mother vessel) from the remote-control station (Shore Tugboat Control Station).

Paul monitors the operational data of all the tugboats and can communicate directly with the Captains of the tugboats (John and the rest of the Captains), the Pilot (Nikos) / Captain of the mother vessel and the Moorer (Francisco). Specifically, Paul has continuous access to data related with the status of the tugboats (navigational, machinery, propulsion and hull), as well as data related with the mother vessel and the environmental conditions during towing/berthing operation. Furthermore, the overall status as well as visual representation of the towing/berthing operation are available.

Paul supervises the high-level or goal-based commands which can be provided to the system by the Pilot during each phase of the towing/berthing of the mother vessel.

Based on these commands, the system automatically adapts/ coordinates the swarm's operation to satisfy the required ship maneuver. Paul monitors the respective actions performed by the swarm (e.g., steering and propulsion of the tugboats). Furthermore, Paul supervises the mooring/ unmooring process performed by the mooring units.

Paul has an enhanced situation awareness of the swarm of tugboats, and for this task, he is supported by a decision-support system accounting for every aspect of tug operation. His awareness is based on data collected either in an automated way (e.g., tugboat's sensors, vessel's position and speed, mooring units' sensors) or manually (e.g., from tugboat Captains, the Pilot or the person supervising the mooring process on-site). In case of an emergency or a failure, Paul is also involved in the decision-making process for providing the right guidance.

The remote-control station enables the tugboat's Captains to immediate response for safety issues(s) either by informing and warning Paul or by asking for permission to emergency action from their side. In that respect, the tugboat Captains can intervene in the operation and Paul must be on alert to ensure that the system acts accordingly. Moreover, Paul shall be able to take control at any phase of the operation of the tugboats in case of an emergency.

Paul shall also be informed about the operational readiness of the tugboats before being involved in a specific operation. Furthermore, he would like to be able to monitor more than 2 operations simultaneously which can be in a different towing/berthing phase. Therefore, he needs to be aware of the vessels position and movement in the vicinity of the port area where the tugboats operation takes place. Moreover, Paul shall be able to send another tugboat to assist the operation if needed. Paul also monitors the operation until the safe berth/unberth of the vessels is completed, so he shall be capable of monitoring and receiving data related with the mooring process that can be available to the swarm of tugboats for further actions when needed.

Paul is also in contact with port authority personnel.

5.9 SC9: Scenario 9

Scenario 9 (SC9) for the Robotic Container Handling System

The Robotic Container Handling System scenario starts when the feeder vessel approaches a small SSS port (e.g., Mykonos), where the ship will be moored and containers, which are loaded at a DSS port (e.g., Piraeus), will be offloaded on the quay. Because the onboard robotic crane is designed to operate autonomously, it does not need an onsite or an onboard crane driver, nor a safety officer on deck. The camera's, mounted on the robotic crane, can detect obstacles and possible unsafe situations, based on an accurate 3D-world model of the local situation and object recognition algorithms. The thus created and maintained world model also provides the robotic crane with the necessary location coordinates, distance to objects, container ID, the position of the doors, and other relevant operational directives. The container optimising algorithm provides real-time crane sequence planning to optimise the efficiency of the offloading.

Despite the high level of self-sufficiency of the robotic crane, the loading and offloading process is supervised by a remote operator, called Otto, who works at a Shore Control Centre (SCC) located at a remote location (see figure 3 below). Remote supervisory control is necessary because during the operation it might be inferred that safety is compromised due to unauthorised people or vehicles (e.g., a bystander) within the offloading area. To solve these kinds of situations, the crane needs help from the remote operator. The (future) remote operator will have access to communication with which to contact the local port authority, named Tessa, and ask to take action to direct the object out of the way.



Figure 3 An artist impression of the Robotic container handling system scenario

Within the SCC, a software component based on Artificial Intelligence (AI) supports all the SCC-operators. We refer to this AI-component as the Intelligent Operator Support System (IOSS). IOSS keeps track of multiple loading and offloading operations and performs risk assessment to update the remote operator sufficiently in advance. The challenge for IOSS is to present the identified risks in an understandable way and offer explanation and situational awareness, either on its own initiative or on operator request. Furthermore, IOSS will relay any information requests or control signals to the robotic crane.

As soon as the last container has been put on board, the robotic crane resets to its seagoing position and the feeder vessel leaves port and heads towards its next destination.

5.10 SC10: Scenario 10

Scenario 10 (SC10) for the MOSES Innovative Feeder Vessel, on behalf of the Bridge Crew Member

Hans is a Bridge Crew Member who works on a container feeder vessel.

He is responsible for the loading and offloading operations of the containers in the Deep-Sea Shipping Port and the Short Sea Shipping Port (figure 4). Furthermore, Hans is assisting the Captain in the navigation of the container feeder vessel and the communication with the Harbour Master/Traffic Control Centre and the Shore Control Centre Operator.

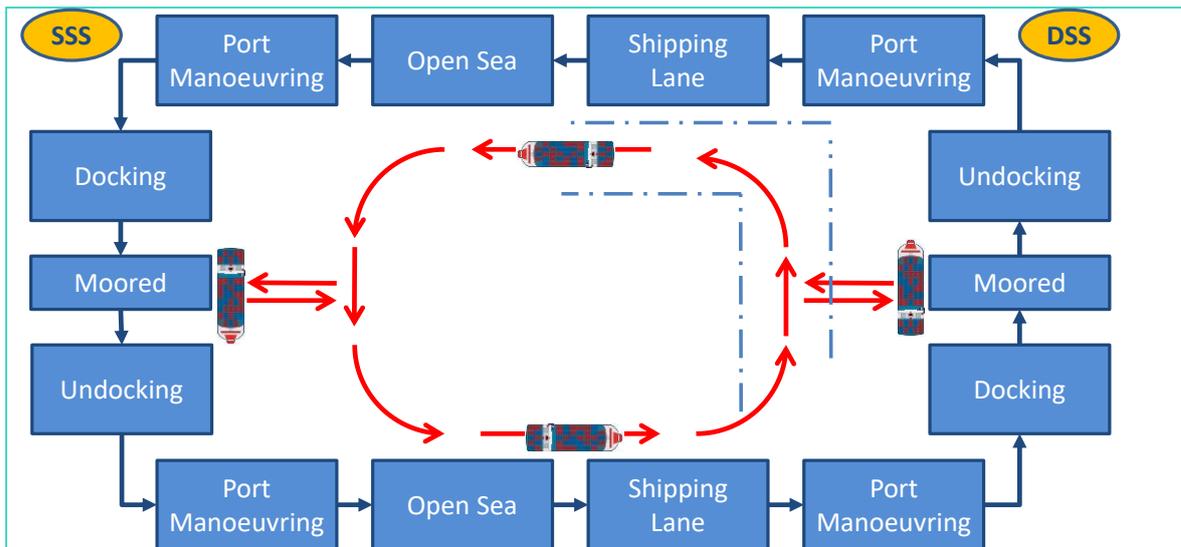


Figure 4 Process of Manoeuvring, Docking, Mooring and Undocking

When the vessel is in the DSS, Hans provides the cargo planning, fuel levels, battery charge status and ballast water levels to the loadmaster. For the new loading, the stability of the vessel is to be assured. Before the ship leaves the harbour the lashing of the cargo is to be controlled. During the transit, Hans is responsible for the control of the status of the cargo as well for damages, leakages and lashing condition.

The sailing schedule of the feeder is based on a roundtrip between a DSS port (e.g., Piraeus Container Terminal) and a number of SSS ports, (e.g., the port of Mykonos).

Each round trip starts in the DSS where the full containers are picked up. The trip starts with the undocking of the vessel. At this moment this is done manually. In the future this process might be automated in the DSS port when the MOSES AutoMoor system is installed.

Once the vessel has undocked, the port manoeuvring is started on the way to the shipping lane. The port manoeuvring is an intensive process as it requires the highest level of attention for the navigation of the vessel and the communication with the Pilot (if required), the Traffic Control Centre and the Shore Control Centre.

In the shipping lane, the navigation of the vessel is based on the time schedule of the vessel, speed limits and other traffic in the sailing area.

At open sea, Hans must discuss the routing of the vessel to the next port with the Captain. The route is optimised for timely arrival and fuel efficiency by the Shore Control Centre Operator and has been sent to the crew on board prior to departure. The route is optimised based on departure and arrival times, weather conditions, loading conditions. During open sea transit the vessel navigation may be autonomous, with the Bridge crew and Shore Control Centre operator(s) present to supervise the safe performance of the ship.

When the vessel approaches the SSS port, Hans must contact the local port authority and discuss the arrival of the vessel. Together with the local port authority and the Shore Control Centre, the port manoeuvring will be prepared and executed.

The next phase is the docking, which is in the SSS a manual procedure. This requires communication with the Tallymen (sailors) and the Captain to perform this manoeuvre in a safe way.

The docking phase is followed by the mooring phase. The vessel may be moored manually, but for short stops in SSS the vessel can be kept against the quay side fenders using the vessel propulsion system. The vessel has DP station-keeping capabilities to make sure that it can safely manoeuvre in port, while exposed to weather and wave conditions.

Now Hans is sure that the vessel is safely moored, the offloading and loading of the containers can be done using the on the feeder vessel installed robotic container-handling system. The vessel crew will initiate the automatic offloading process only after they are certain that no port personnel or vehicles are present at the quay side next to the ship.

The undocking of the vessel follows a similar procedure as the docking. Hans is taking care of the coordination of the work between the Tallymen and the Captain. On the round trip several others SSS ports can be visited, where the same procedures are followed. Finally, the vessel heads again for the DSS port of Piraeus.

The MOSES innovative autonomous feeder will reduce the number of tasks that Hans will have to take care of. The route planning, navigation at open sea and monitoring of the vessel systems will be done autonomously or from the Shore Control Centre. If necessary, the Shore Control Centre can also assist during manoeuvring in complex situations.

5.11 *SC11: Scenario 11*

Scenario 11 (SC11) for the MOSES Innovative Feeder Vessel, on behalf of the Shore Control Centre Operator

Nixie is a Shore Control Centre Operator at the Shore Control Centre. She is responsible for the control and monitoring of the autonomous operation of the various container feeder vessel of the shipping line. The container feeder vessels operate between the DSS port and several SSS ports.

Before the vessel leaves the port, Nixie checks with the Bridge crew member Hans the status of the operational parameters of the vessel and confirms the routing. Next a plan is agreed, which part of the route will be performed in autonomous mode. In this part, Nixie is responsible for the monitoring of the sailing of the vessel. The crew on board of the vessel is doing other tasks or taking a rest.

While approaching the water lines of the next port, Nixie contacts Hans to transfer the operation of the vessel to the crew on board. If necessary, Nixie can also assist during the manoeuvring in complex situation.

5.12 SC12: Scenario 12

Scenario 12 (SC12)

Gerco is an executive manager in a Container Shipping Company that operates feeders. His main role is to support strategic decisions relating to the feeder lines that the company maintains, which include deciding what types of vessel will serve the lines most cost-effectively.

Gerco's decisions to establish a new feeder line and what type of feeder vessel to use are affected by several factors, including the following:

- The amount of cargo (demand) that is available for transportation,
- The stricter regulatory requirements for lowering emissions as well as the tendency for decarbonisation and the demand for greener shipping by the clients,
- the need to minimise cargo delivery times to the customer,
- the difficulties with delivering cargo to small ports, where infrastructure may be limited or non-existent.

A new innovative feeder vessel with a flexible design will enable Gerco to cover a broad range of operational contexts that satisfy the needs of his clients for a cleaner and more efficient logistic chain.

6. MOSES Use Cases

Within this chapter, relevant Use Cases from the scenario definition will be developed and presented. Table 5 provides an overview of the relations between the defined use-cases and the developed scenarios. Use Cases that correspond to more than one scenario, showcase the interdependences between the involved personas and MOSES innovations.

A Use Case describes a high-level action using details about workflow, triggers and conditions which need to occur to fulfil the action. Each of the below developed 8 use-cases is presenting both textual and graphical by using Unified Modeling Language (UML) activity diagrams.

Table 5 Use Cases associated with the corresponding scenarios

Scenarios	MOSES Innovations					
	MOSES AutoDock		MOSES Innovative Feeder Vessel	MOSES Robotic Container-Handling System	MOSES Recharging Station	MOSES Matchmaking Platform
	MOSES Autonomous tugboat swarm	AutoMoor				
SC1					UCS1a UCS1b	
SC2						UCS2a UCS2b
SC3						UCS3
SC4						UCS4
SC5		UCS5				
SC6	UCS5	UCS5				
SC7	UCS5					
SC8	UCS5					
SC9				UCS6/ UCS7		
SC10			UCS7			
SC11			UCS7			
SC12			UCS8			

A general template has been used (table 6), in order to facilitating the reporting of each Use Case in a coherent structure.

Table 6 Use Case Template

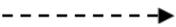
ID: UCSx
Use Case title: <title>
Associated Scenario(s): <text>
Personas involved: <text>
Short Description: <text>
Main Process: <text>
UML activity diagram: <text>

Table 6 includes the following information:

- The ID, which gives a unique identifier for the Use Case that is used in later sections and it will be used during the project to reference it.
- The Use-Case title, which explains what the use-case will be about.
- The Associated Scenario field, which relates the Use Case to one or more scenarios.
- The Personas involved field, which makes a reference to the corresponding to the Use Case, personas.
- The short description field, which gives in a nutshell an outline of the Use Cases processes that are going to be thoroughly described in the next step.
- The main process field, which gives the step-by-step description of the referenced use-case.
- The UML activity diagram field, which contains the graphical representation of the step-by-step process described in the previous field, using a diagram that includes the personas and their interaction with MOSES innovations, as well as the sequence of actions.

Each Use Case is graphically represented by UML (Unified Modelling Language) Use Case activity diagrams, using the following icons and symbols (table 7):

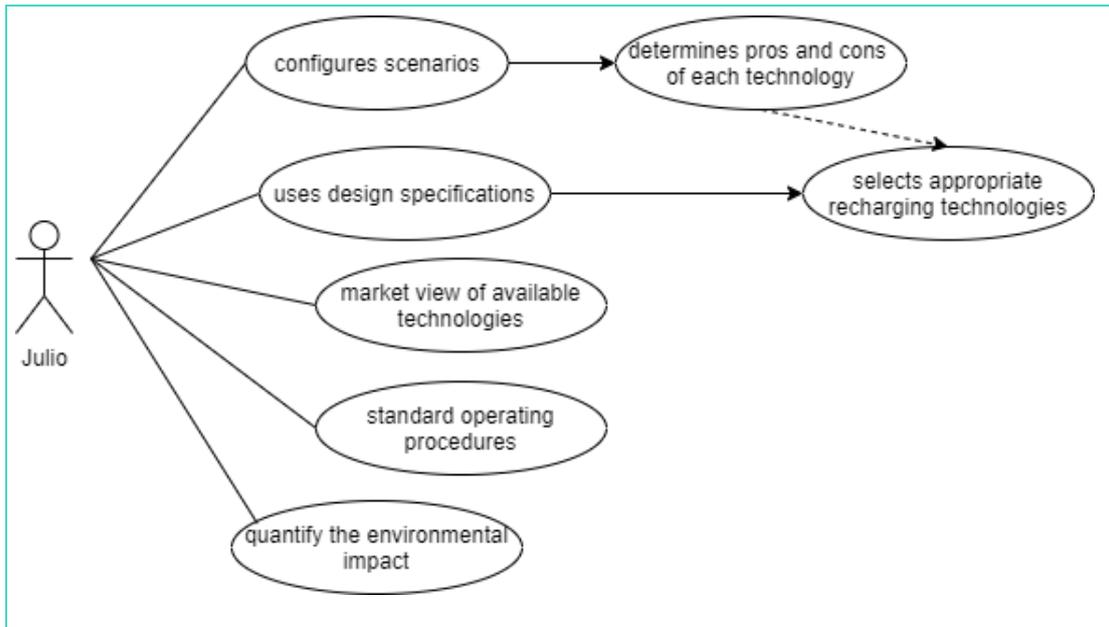
Table 7 UML Annotation

Graphic Symbol	Name	Meaning
	Persona	Personas are participants playing a specific role.
	System Process	System processes are functionalities of the system as perceived by personas. When linked to a persona through an association, a system process describes what the persona can do with the system.
	System Association	A system association between a persona and a process means that the actor can “participate to” or “is a user of” the process.
	System Specialisation relationship	A system “specialisation” relationship means “inheritance”. The specialised process relies on the original one while adding extra functionalities.
	System Dependency relationship	System “Dependencies” indicate if a process depends on another one. It refers also to system functions that fulfil a process.

	Non- system Process	Non-system processes are functionalities external to the MOSES system.
	Non- system Association	A non-system association means that the actor can “participate to” or “is a user of” a non-system process.
	Non- system Dependency relationship	Non system “Dependencies” indicate if a non-system process depends on another one. It refers also to non-system system functions that fulfil a non-system process.

6.1UCS1: Scenario 1 Use Cases (a & b)

UCS1a
Assessing the technical feasibility of shore power connection system
Associated Scenario(s): SC1
Personas involved: Julio, member of the Port management staff
<p>Short Description:</p> <p>The Use Case is focused on addressing the uptake and feasibility of the MOSES Recharging Station. This will result from the evaluation of each power infrastructure arrangement and of the shore power connection.</p>
<p>Main Process:</p> <ul style="list-style-type: none"> - Julio is able to configure scenarios for the use/uptake of the innovation while considering as input parameters the economic, technical and operational conditions of the port as well as environmental goals that need to be achieved. - Julio is able to determine the advantages and disadvantages of each recharging technology in function of the type of the vessel to be supplied, port configuration and other port services provided at the same berth. - Julio uses the design requirements/specifications to guide him during the selection of the appropriate battery recharging technologies for the fulfilment of the installation. - Julio views in a comprehensive way all the battery recharging technologies available in the market including their technical characteristics. - Standard operating procedures are applied aiming to harmonise the safe use of the innovation as part of the port activities. - Julio can quantify the environmental impact emerging from the adoption of the innovation.
UML Activity diagram:



UCS1b

Establishing service provisioning models for the MOSES Recharging Station

Associated Scenario(s): SC1

Personas involved: Julio, member of the Port management staff

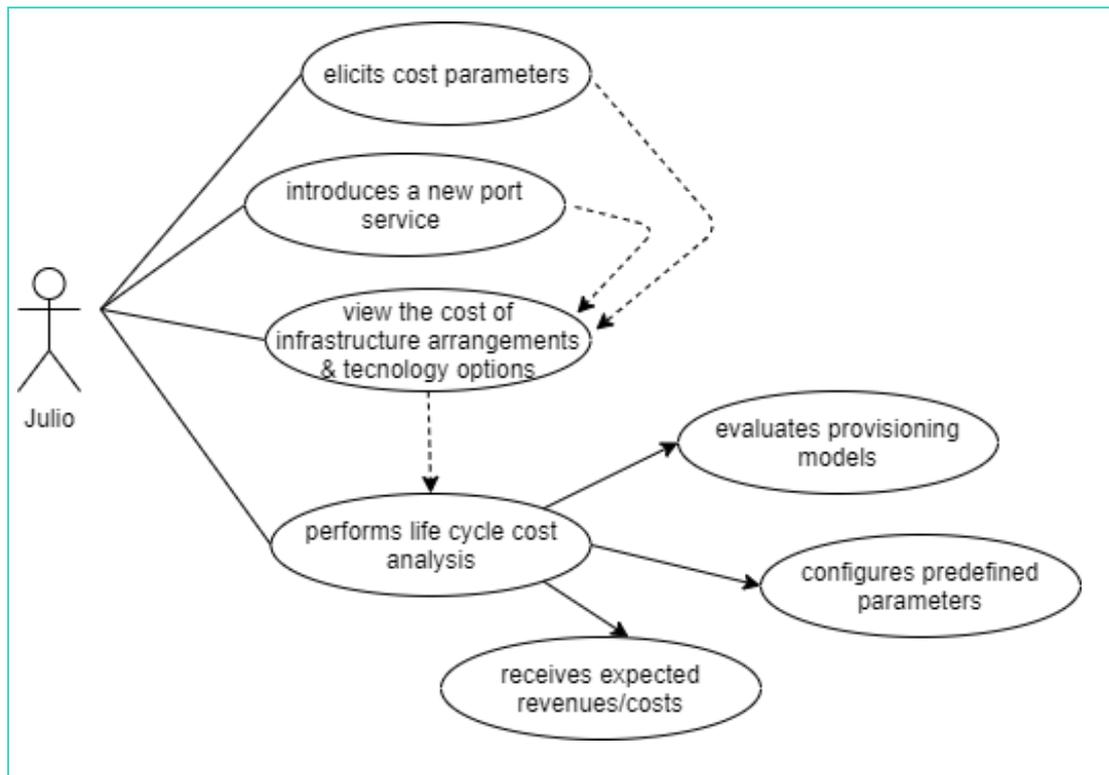
Short Description:

The Use Case covers the economic aspects around the MOSES Recharging Station as well as viability of the foreseen business proposition.

Main Process:

- Julio can elicit information about the cost parameters for the implementation of the recharging station.
- Julio can introduce a new port service that will be simultaneously provided with other port activities, avoiding significant interference between them, and assuring the safety of the whole port operative.
- Julio can view the costs of each primary power infrastructure arrangement and automated shore power technology option.
- The possibility to perform life cycle cost analysis is provided. Julio can evaluate different provisioning models, configure/adjust predefined parameters, and receive the expected revenues/costs for both short-term and long-term.

UML Activity diagram:



6.2 UCS2 Scenario 2 Use Cases (a & b)

UCS2a

Assessment of optimal routing in supply chain management

Associated Scenario(s): SC2

Personas involved: Fotis, the shipper

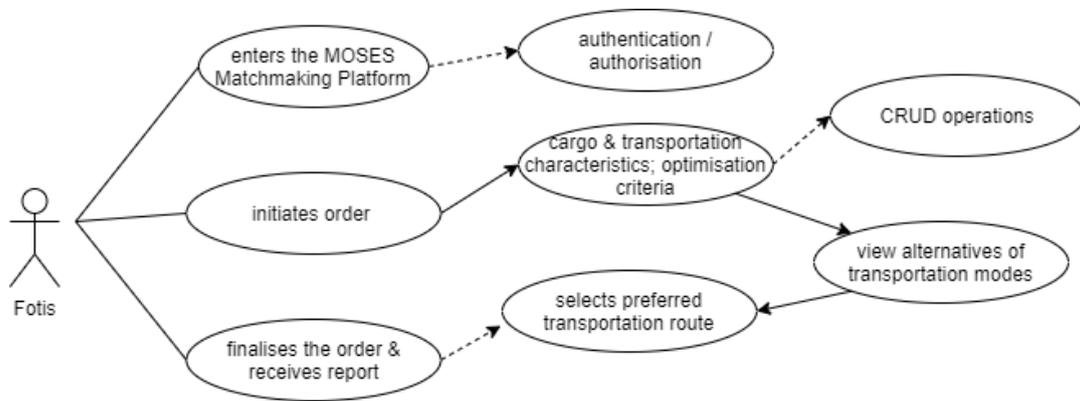
Short Description:

The Use Case covers the interaction of a shipper with the MOSES matchmaking platform aiming to assess and identify the optimal route during the cargo sending process.

Main Process:

- Fotis logs in to the MOSES Matchmaking Platform.
- Fotis can initiate the order (process for the transportation of his cargo).
- The Matchmaking Platform provides dedicated interfaces enabling Fotis to insert details about his cargo (i.e., type, volume, weight) and the transportation characteristics/requirements (i.e., destination, departure/arrival date). Fotis can also select different optimisation criteria (i.e., cost, environmental impacts) or combinations of the latter and other hard constrains (i.e., dangerous goods, refrigerated cargo, high quality of service) that underpin the transportation.
- Based on the input parameters and the current market transportation offers, the platform provides alternatives of available transport modes to reach the destination, ranked according to the specified criteria. The platform supports user friendly representation of the results.

- Fotis can edit his order and the platform provides the re-calculated logistic routes.
- Fotis proceeds with the selection of the preferred route. Upon the finalisation of the order, the actor receives a report with the confirmed order details (either via email or downloadable through the system).

UML Activity diagram:

UCS2b
Inter-actors order assignment and acceptance
Associated Scenario(s): SC2
Personas involved: Fotis, the shipper

Short Description:

The Use Case covers the interaction between different actors involved in the supply chain management towards the assignment and acceptance of orders for cargo transportation. It focuses on the “shipper” persona.

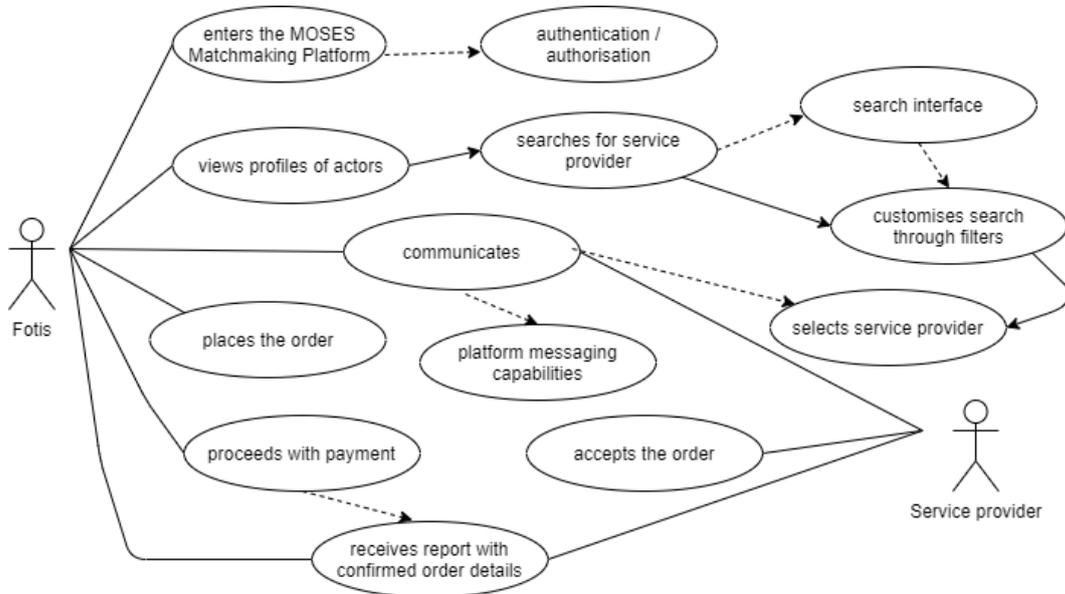
Main Process:

- Fotis logs in to the MOSES Matchmaking Platform.
- Fotis is able to view and browse the profiles of other relevant actors involved in the supply chain (i.e., freight forwarding companies).
- Search capabilities are provided in the respective interface of the MOSES Matchmaking Platform, enabling Fotis to easily identify and select the desired service provider (i.e., considering past successful collaborations).
- Additionally, dedicated interfaces enable Fotis to insert details about his cargo (i.e., type, volume, weight, dangerous goods, etc.) and the transportation characteristics/requirements (i.e., destination, departure/arrival date) and filter the service providers satisfying these needs (i.e. a freight forwarding company, operating in southern Europe and specialised in dangerous goods transportation services);
- Fotis is able to select the desired service provider and communicates all the needed characteristics of the transportation, while requesting the price for the provision of the service.

- Harnessing the messaging capabilities of the platform, the service provider (freight forwarding company) communicates the information. Upon agreement, Fotis places the order that is subsequently accepted and by the service provider.

Finally, both parties receive a report with the confirmed order details (either via email or downloadable through the system).

UML Activity diagram:

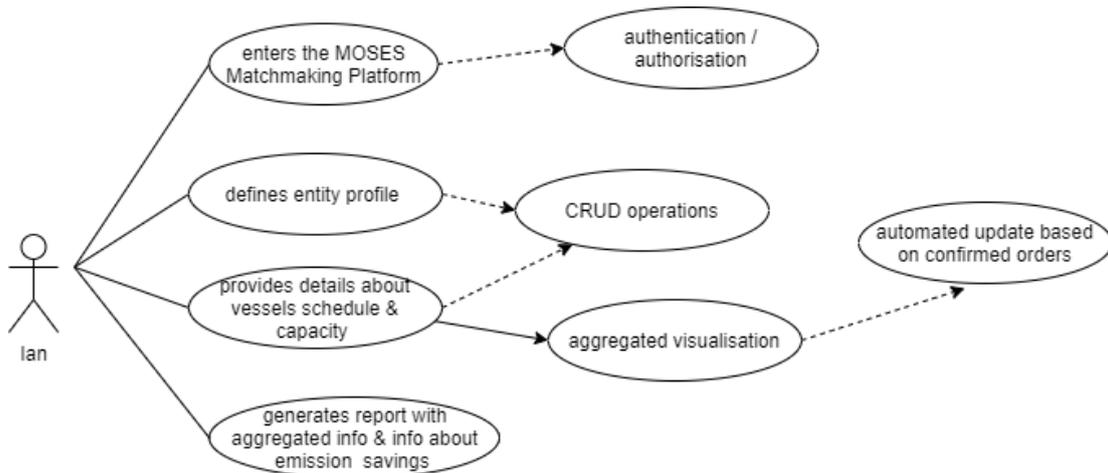


6.3 UCS3 Scenario 3 Use Case

<p>UCS3 Addressing demand-supply for carrier services</p>
<p>Associated Scenario(s): SC3</p>
<p>Personas involved: Ian, the Carrier</p>
<p>Short Description: The Use Case covers the interaction of a carrier with the MOSES matchmaking platform aiming to ensure viable and balanced product supply-demand and container flow.</p>
<p>Main Process:</p> <ul style="list-style-type: none"> - Ian logs in to the MOSES Matchmaking Platform. - Ian can insert details about the profile of his entity (i.e., define locations of transportation route (lat, long) etc.) through dedicated interfaces provided by the platform. This information can be updated at different time instances as needed. - Ian can provide details about the schedule of the vessels operating in the transportation route/itinerary (route alternatives) as well as their capacity both in terms of container availability, size and cargo characteristics (available slots in each route). as well as of the associated costs.

- Following this, the information provided is displayed/visualised in an aggregated way (i.e., grid-based view and/or categorisation per day or week) while enabling Ian to update it (in the case of manual entry).
- The capacity status is updated automatically within the system in the case of orders confirmed/accepted through the MOSES Matchmaking Platform.
- Ian can generate a report with the aggregated information also including information about the emission savings achieved.

UML Activity diagram:



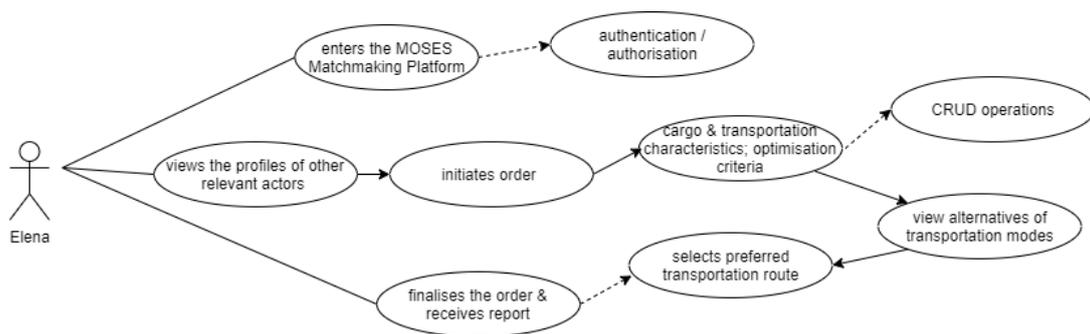
6.4 UCS4 Scenario 4 Use Case

<p>UCS4 Addressing demand-supply for freight forwarder services</p>
<p>Associated Scenario(s): SC4</p>
<p>Personas involved: Elena, the freight forwarder</p>
<p>Short Description: The Use Case describes the interaction of an Operations Manager of a freight forwarder with the MOSES matchmaking platform towards the selection of the most suitable cargo transportation route.</p>
<p>Main Process:</p> <ul style="list-style-type: none"> - Elena logs in to the MOSES Matchmaking Platform. - Elena can involve in the supply chain. - Elena can initiate the order (provide details about his cargo). - The Matchmaking Platform provides dedicated interfaces enabling Elena to insert details about his cargo (i.e., type, volume, weight) and the transportation characteristics/requirements (i.e., destination, departure/arrival date). - Based on the input parameters and the current market transportation offers, the platform provides alternatives of available transport modes to reach the destination, including the associated costs. The platform supports user friendly representation of the results, including grouping of the alternatives

per transport modes as well as alternatives that might combine different transport modes. The characteristics (i.e., timing, stops, costs, etc.) of each alternative/logistic route will be displayed. The different logistic routes are also visualised in a web.

- Elena can edit his order and the platform provides the re-calculated logistic routes.
- Elena proceeds with the selection of the preferred route. Upon the finalisation of the order, Elena receives a report with the confirmed order details (either via email or downloadable through the system).

UML Activity diagram:



6.5 UCS5 Scenarios 5, 6, 7 and 8 Use Case

UCS5

Approaching a DSS port (towing/ berthing process of the mother vessel)

Associated Scenario(s): SC5, SC6, SC7, SC8

Personas involved: Francisco, the Moorer, Nikos, the Pilot, John, the Tugboat Captain and Paul, the Shore Tugboat Control Station operator

Short Description:

This Use Case describes the interaction between the personas directly related with the MOSES AutoDock system (MOSES autonomous tugboats swarm and MOSES AutoMoor System) so that the towing/ berthing of a large containership which is approaching a DSS port (e.g., Piraeus, Valencia) is performed in the shortest possible time while complying with a high safety standard.

Main Process:

Phase 1: Preparation of the towing/berthing process

- Nikos, the Pilot, is onboard the containership. He has been installed in command and has settled all the preparation actions (communication with tugboats, crew, port, Vessel Traffic Service). Nikos has already required a service specifying the number of tugboats and their characteristics (e.g., a swarm of two autonomous tugboats) needed for the specific operation, as well as the type of towing/berthing in each phase (push etc.) and the desired

route (e.g., terminal 3 dock number 3). Furthermore, Francisco, the Moorer, has received information about the specific mooring operation.

- Paul, the remote-control operator, is at his desk and receives the information about the intended operation. From the Shore Tugboat Control Station, he has access and monitors in real-time all the operational data of the assigned tugboats for this task. Specifically, he monitors data related with the tugboat's operation (navigational, machinery, hull) as well as visual observations through the installed cameras and continuous communication with John and the other tugboat Captain(s). In overall, the Shore Tugboat Control Station provides a safety level of the process based on a risk-based assessment.
- The tugboats approach the containership (it can be done also by John and the other Captains manually) and are in a position to start the process. This is the moment for passing to the automatic swarm operation, so a detailed check and a confirmation for the transition is required.
- Paul checks through the Shore Tugboat Control Station that all the data and the resources required for a safe process are available (e.g., communication channels between the swarm, the mother vessel, the remote-control and the port have been established). The Shore Tugboat Control Station performs the checks, and Paul verifies again with the tugboats' Captains.
- The Shore Tugboat Control Station initiates the transition providing that the safety level is satisfactory.

Phase 2: Towing/berthing process

- The intended operation has been initiated.
- The Deck crew establishes the necessary connections where needed (towing cables/ towing ropes etc) and Paul informs Francisco that the vessel is approaching the dock.
- John and the other tugboat Captain(s) monitor, as usual, the manual process and inform the Shore Tugboat Control Station that the connections are ok.
- The Shore Tugboat Control Station initiates the swarm operation. The tugboat Captains (John etc.) and Paul monitor the approach.
- Everything goes as intended.
- Nikos, the Pilot, informs John via VHF that a correction to the route and the speed of the mother vessel is needed, providing specific details– e.g., the speed of the vessel shall be reduced to 5 knots.
- Paul, who receives this information, immediately provides this information to the Shore Tugboat Control Station, which adapts the swarm operation considering also all the conditions at this moment.
- Paul checks that the goal has been satisfied.
- At a later stage, the Shore Tugboat Control Station, informs Paul that the safety level has been degraded in critical mode. It also investigates the root-

cause parameter, based also on the input of the Captains or/and the Pilot, and proposes solutions.

- Paul examines whether the process can be continued by the swarm, or manual operation from John shall be assigned or he needs to take control by himself. He also examines whether the tugboats can continue the operation, or another tugboat is needed.
- Paul hands over the control to John and the other tugboat Captain(s) as the operation will be continued manually, while Paul through the Shore Tugboat Control Station resolves the problem.
- Having the problem resolved, the process is continued again by the autonomous swarm.
- The vessel is close to the dock and Paul informs Francisco that the mooring process will be initiated for him to start supervising the process.

Phase 3: Mooring

- The specific vessel particulars are used to determine how many mooring units the vessel requires to be held securely in the berth. A vessel profile is created by the terminal operator (or the ship agent) prior to vessel's arrival.
- The vessel berth position provided by port operations to suit operational needs is used by Francisco to determine how many mooring units along the berth are used for the specific vessel mooring.
- At the time the vessel is approaching the dock, the mooring units receive a signal and are automatically activated and shifted from a parked position to a position ready for vessel mooring. Paul is monitoring the process through the Shore Tugboat Control Station and Francisco is monitoring the process on-site.
- The sensors on the mooring units recognise also that the vessel is in position and automatically start their mooring sequence of securely fixing to the vessel. Paul, the remote-control operator, Nikos, the Pilot and Francisco, the Moorer, are monitoring the process and are ready to intervene if something goes wrong.
- The mooring units sense that the mother vessel is approaching with speed larger than the maximum allowable, and send a signal to the tugboats / Shore Tugboat Control Station for a corrective action.
- Tugboats' operation is adapted automatically through the Shore Tugboat Control Station (Paul and John monitors this action) and now the vessel's speed is reducing.
- The mooring units send a signal to the tugboats/ Shore Tugboat Control Station that the vessel's speed is in the right limits.
- Once the mooring units have secured the vessel, the mooring units automatically send a signal to the autonomous tugboats. Paul, the remote-control operator, and Francisco verify that the process has been completed. Nikos, the Pilot, is informed that the vessel has been securely berthed.

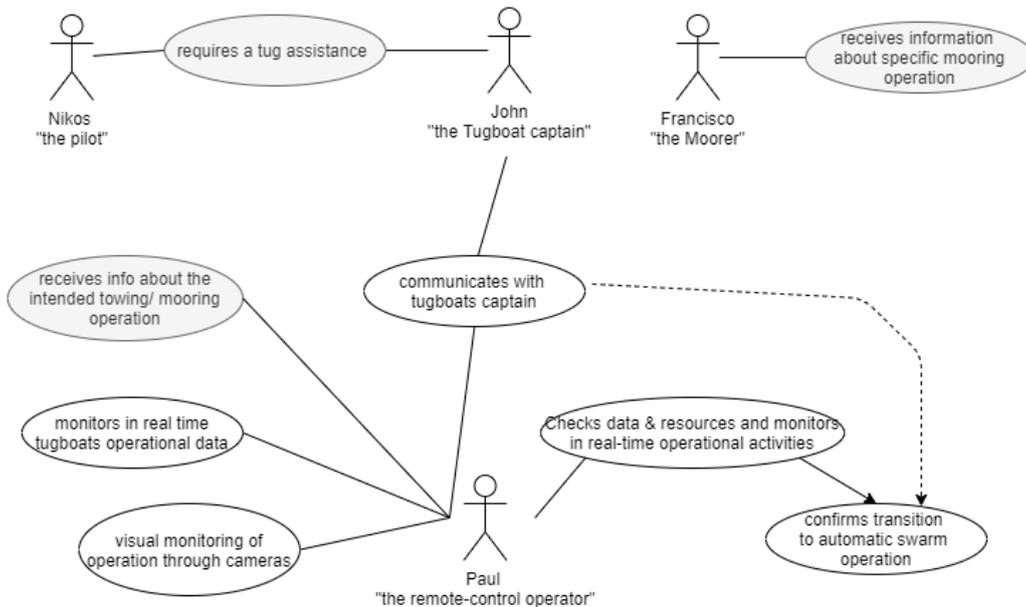
- Paul initiates the departure of the tugboats swarm from the berth position. John and the other(s) tugboat Captain(s) are monitoring the process.

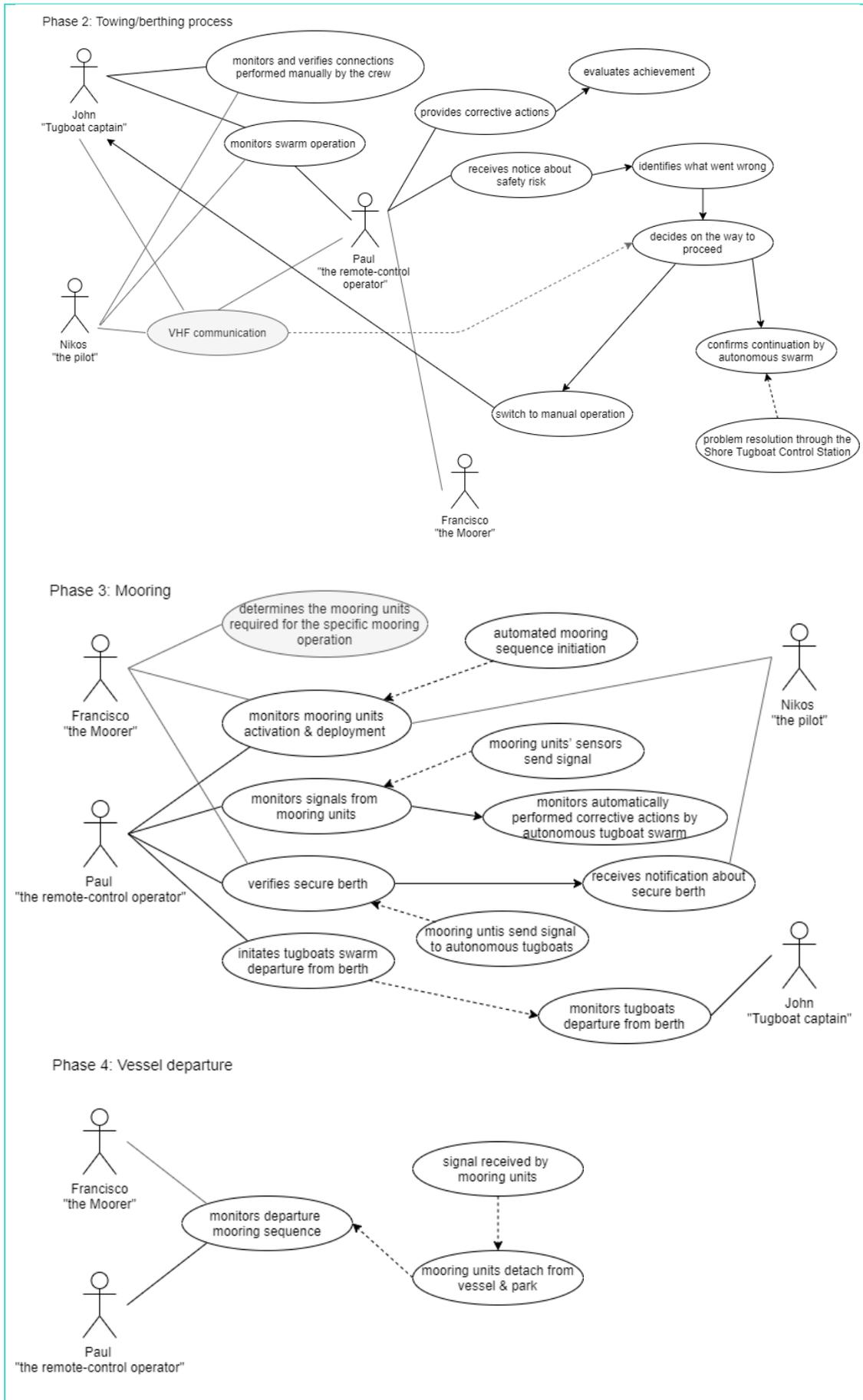
Phase 4: Vessel departure

- When the terminal operations are completed and the vessel is ready to depart, Nikos and the tugboats autonomous swarm are ready and in-place. The mooring units receive a signal to proceed with the departure mooring sequence. Francisco is monitoring the process.
- Once the mooring units have been signalled, they will automatically detach from the vessel and return to their parked position. Paul is monitoring the process through the Shore Tugboat Control Station and Francisco is monitoring the process on-site.

UML Activity diagram:

Phase 1: Preparation of the towing/berthing process





6.6 UCS6 Scenario 9 Use Case

UCS6

Approaching a Short Sea Shipping port

Associated Scenario(s): SC9

Personas involved: Otto, the Shore Control Centre operator for the RCH and Tessa, the terminal operator

Short Description:

This Use Case describes the interaction between the personas and systems involved with loading and offloading operation in a SSS port (e.g., Mykonos, Gandia, Sagunto) with the MOSES robotic container crane.

Main Process:

Ship approaching port.

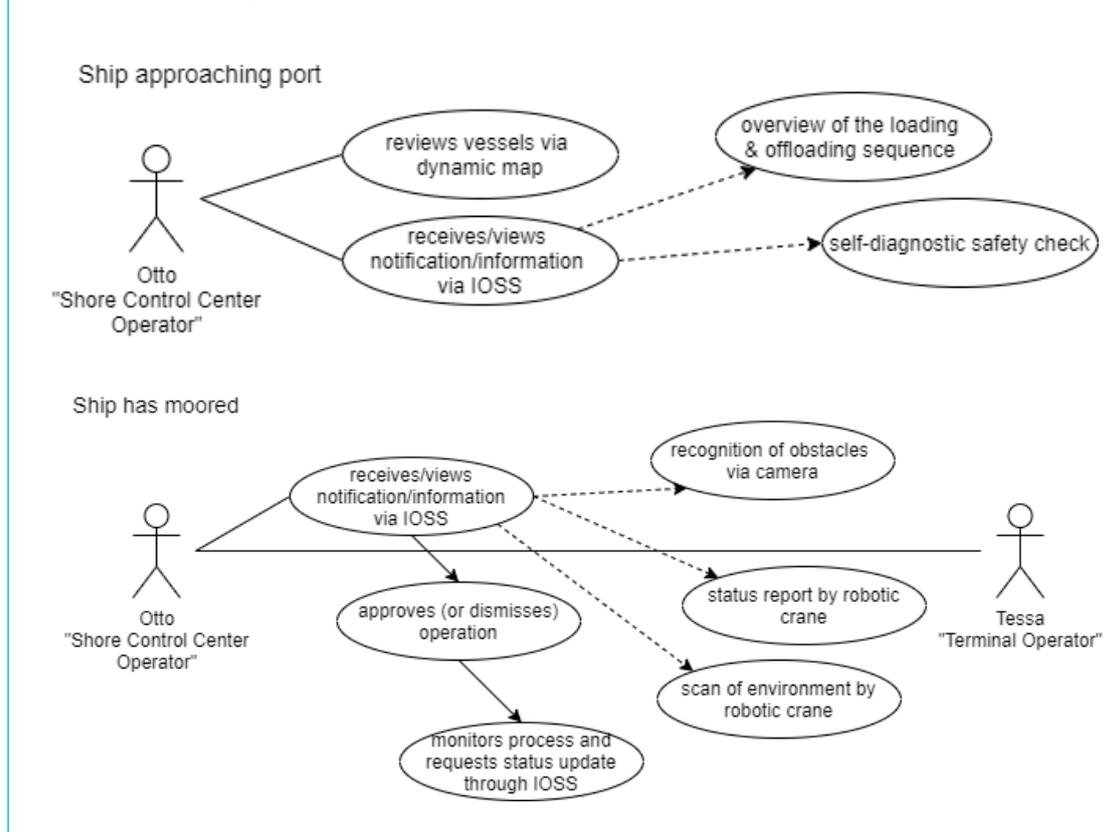
- Otto, sitting behind his desk, reviews all the vessels on the dynamic sea map and sees that one is close to port.
- A few minutes later, IOSS, the Intelligent Operator Support System, asks whether Otto is ready to supervise this vessel.
- IOSS provides an overview of the loading and offloading sequence. For this vessel two container are taken onboard (loading) and one container is taken off board (off loaded) and put on the quay.
- Based on this handshake between Otto and the IOSS, the responsibility for the ship has now been transferred to Otto.
- A self-diagnostic safety check is performed by IOSS and the vessel information system, and a summarised digital overview is presented to Otto. It includes any failures and special remarks regarding the system, vessel, environment, or freight.

Ship has moored.

- The camera mounted onto the robotic crane checks for obstacles.
- A truck is detected that is blocking the crane movement.
- Otto receives a notification from IOSS and decides to contact Tessa. Both agree that the truck should be moved for safety reasons.
- Tessa kindly asks the truck driver to move the truck.
- Now that there are no obstacles in the way, the robotic crane performs a full scan of the environment, by moving the boom of the crane to make a 3D-map.
- The robotic crane reads in the container loading and offloading sequence and checks for issues that prevents for correct sequencing (obstacles, containers missing, containers unreachable etc.).
- All relevant information, including a status report of the robotic crane, the planning and the meta data map are sent to IOSS. IOSS does not see issues preventing a safe operation.
- The robotic crane asks for approval to start the loading and offloading sequence. IOSS relays the question to the Otto.
- Otto approves the loading/offloading process.
- The Robotic crane starts the offloading procedure.

- IOSS monitors the robotic crane.
 - Otto is already engaged in monitoring another ship.
 - IOSS shows its icon, with a slowly pulsating green dot to show everything is working normal.
 - Otto decides to ask for a situation report on the progress and potential risks of the procedure. Everything goes well, no action is needed.
 - After a while IOSS notifies Otto that the procedure ended successfully.
- The ship takes to sea.

UML Activity diagram:



6.7 UCS7 Scenarios 10,11 Use Case

UCS7

Transfer of containers from a DSS port to a SSS port

Associated Scenario(s): SC9, SC10, SC11

Personas involved: Hans, the Bridge Crew Member, Nixie, the Shore Control Centre Operator for the feeder and Otto, the Shore Control Centre Operator for the RCH

Short Description:

This Use Case describes the interaction between the personas and the systems directly related with the MOSES innovative feeder vessel so that the loading, the transfer and the offloading of the containers is performed from a DSS port (e.g., Piraeus, Valencia) to a SSS port. Although the MOSES feeder may operate at different levels of automation and human presence, in this Use Case it is assumed that it is manned, sails autonomously at open sea under the supervision of a Shore Control Centre (Phase 2a) and/or in an enhanced manual mode with decision support from a Shore Control

Centre (Phase 2b), and is manually navigated during port departure/approach. Furthermore, at the berthing in the SSS port (Phase 3), the vessel is manoeuvring by her own means (the SSS port is not fitted with the AutoDock system).

Main Process:

Phase 1: Loading of the containers in the DSS port and preparation for departure.

- The MOSES innovative feeder vessel has entered the DSS port and has been berthed at the quayside. The port approach has been conducted with conventional navigation, after switching from the autonomous navigation mode in the open sea leg.
- Hans, the Bridge Crew Member who is (among others) responsible for the loading and offloading process, has assured the stability of the vessel, has carried out all the necessary checks, and has performed the cargo planning based on the routing plan optimised and agreed between himself and Nixie, the Shore Control Centre Operator. The loadmaster is informed accordingly and the loading of the TEUs has taken place, using DSS port's gantry cranes.
- Hans checks the container cargo lashings, the fuel levels, the battery charge status, the ballast water levels and ensures that the required communication channels are available (e.g., communication with Nixie). Hans notifies the Captain, and the feeder vessel is ready to depart from the DSS port.
- The trip starts with the undocking of the vessel (the process is performed manually).

Phase 2a: Open sea navigation of the feeder vessel / Sea passage (autonomous navigation)

- The vessel manoeuvring has taken place and the vessel is on her way to the shipping lane (manual process).
- Based on the plan, already agreed between Hans and Nixie, this is a point to pass from manual operation to autonomous. The Captain verifies that this can be performed and informs Hans accordingly. Hans informs Nixie. A detailed check is performed from Hans and Nixie.
- Nixie initiates the transition, provided that the safety level, as has been assessed by the Shore Control Centre, is satisfactory.
- Nixie is monitoring the safe performance of the ship based on the Shore Control Centre information and is ready to communicate with Hans when an emergency situation or a malfunction during the operation occurs. Additionally, during the transit, Hans is responsible for the control of the status of the cargo.
- When the vessel is approaching the SSS port, Hans has to contact the local port authority and discuss the arrival of the vessel. Nixie, according to the routing optimised plan, this is a moment to pass to manual operation and the Captain verifies that this can be performed; Hans and Nixie are informed accordingly.
- Nixie initiates the transition, provided that the required controls have been performed. The Captain has full control of the vessel's navigation.

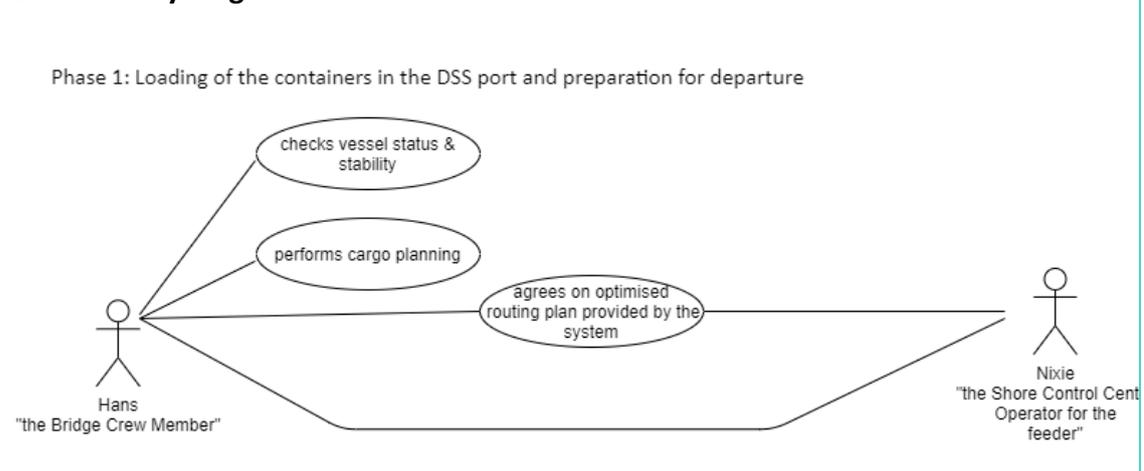
Phase 2b: Open sea navigation of the feeder vessel / Sea passage (enhanced manual navigation)

- The vessel manoeuvring has taken place and the vessel is on her way to the shipping lane (manual process).
- After contacting the local port authority, Nixie informs Hans that there is a delay in the SSS port. Considering fuel efficiency, weather conditions, just in time arrival and safety, Nixie informs that ship speed shall be optimised in several parts of the trip and she will provide such information to Hans.
- The vessel arrives at the SSS port without the need to wait. Hans has carried out all the necessary facilitations with the port authority.

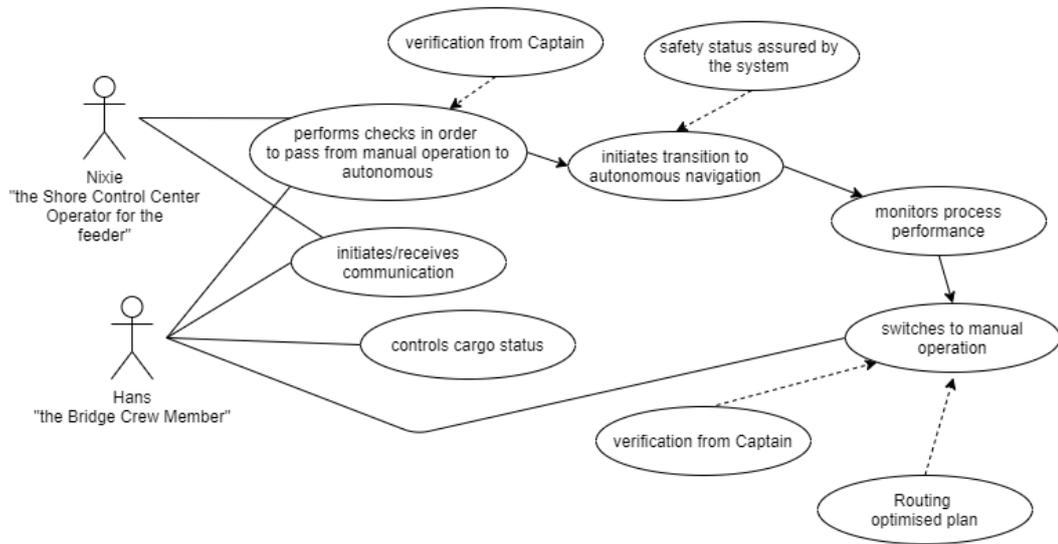
Phase 3: Berthing at the SSS port, offloading of the containers.

- The feeder vessel enters the SSS port in manual navigation mode and it uses her own means for manoeuvring and berthing purposes. Because another vessel is leaving the quay, Dynamic Positioning (DP), is employed for the feeder to maintain her position safely for a short time while waiting to enter the port. Furthermore, during short stops and where fixed mooring is not necessary, DP can be used (this will depend upon the situation in the ports that will be called upon and the respective port's regulations).
- The feeder vessel now has reached her position at the quay and Hans checks with the help of Nixie, several systems (e.g., ship is secure and stable, machinery and power needs for the crane can be satisfied) in order to assure that the initiation of the offloading with the RCH can commence.
- Then Hans informs Otto, the RCH operator, accordingly.
- The offloading process is initiated. Otto monitors the process. Hans monitors ships' status to ensure that operational conditions during the offloading process are satisfied. For example, in case of a passage of another ship that induces significant motions on the feeder vessel, Hans should inform the RCH operator that the process should pause for a while, until DP readjusts vessel's position. Hans informs Otto that the process can continue.
- Hans and RCH operator agree that all TEUs have been unloaded and the RCH can be reset to its seagoing position.
- The feeder leaves the SSS port in manual navigation mode.

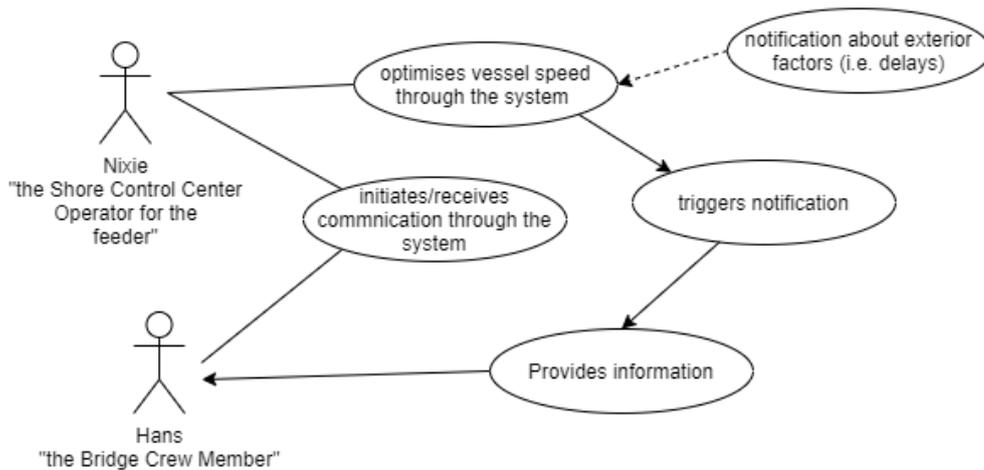
UML Activity diagram:



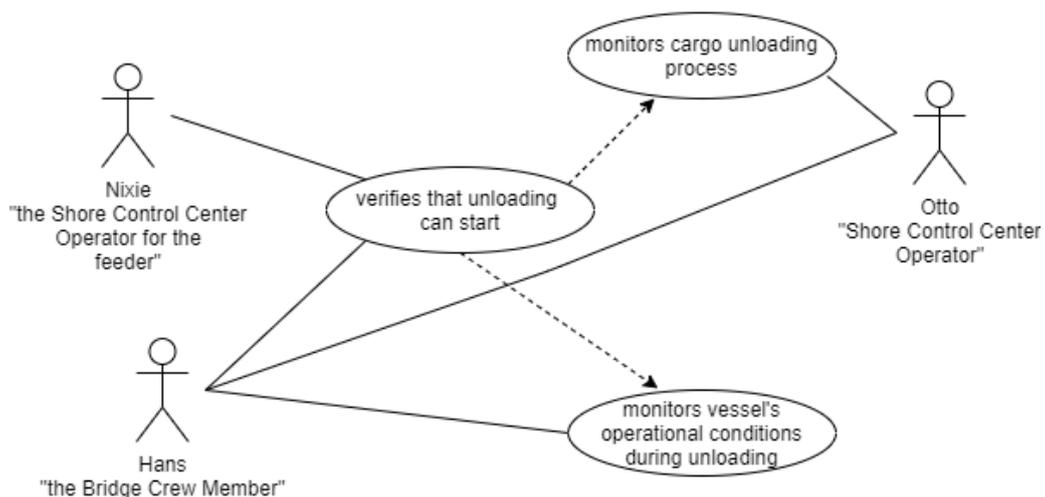
Phase 2a: Open sea navigation of the feeder vessel / Sea passage (autonomous navigation)



Phase 2b: Open sea navigation of the feeder vessel / Sea passage (enhanced manual navigation)

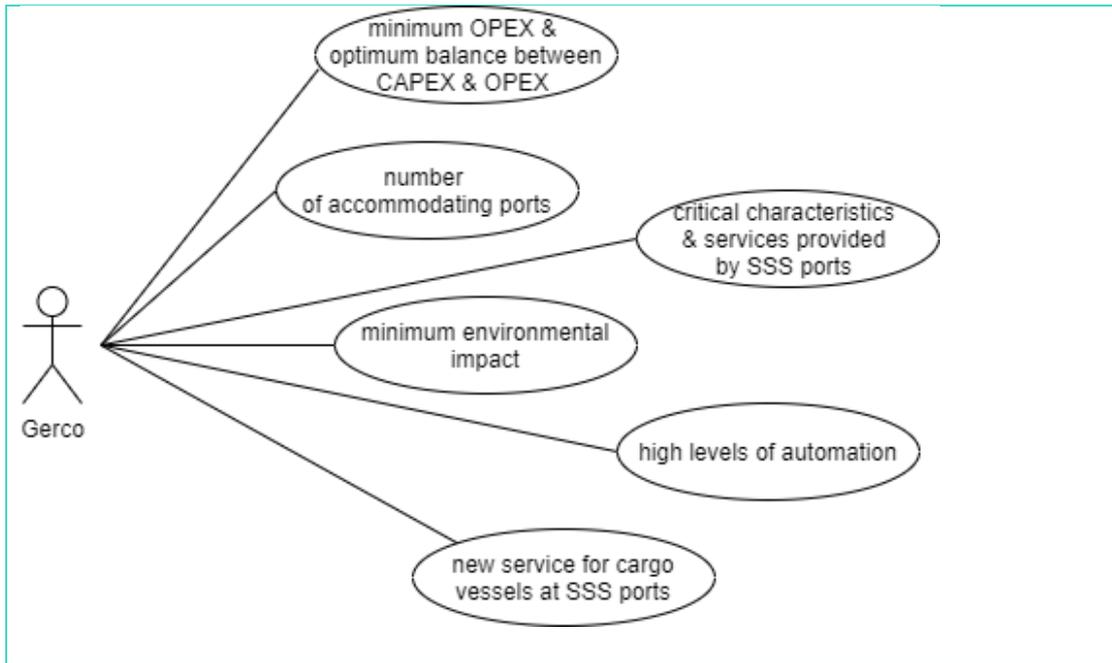


Phase 3: Berthing at the SSS port, unloading of the containers



6.8 UCS8 Scenario 12 Use Case

UCS8
Identification of feeder's functional parameters for optimum operation
Associated Scenario(s): SC12
Personas involved: Gerco, is an executive manager in a Container Shipping Company (Shipping Line)
<p>Short Description:</p> <p>The Use Case describes what Gerco, as the executive manager of a shipping company that operates feeders, needs to optimally operate the MOSES innovative feeder vessel in a line for transporting containers that arrives at a large terminal directly to small SSS ports close to the final destination.</p>
<p>Main Process:</p> <ul style="list-style-type: none"> - Gerco needs to transport cargo cost-effectively, which is affected by the balance between CAPital EXpenditure (CAPEX – the cost to build or buy the ship) and OPerational Expenditure (OPEX – the cost to operate the ship). CAPEX is proportional to the ship's capacity, while OPEX is strongly affected by fuel costs. Most ships are designed to optimally exploit their full capacity, but in the new feeder line the cargo volume to be transported fluctuates (e.g., in each round trip, different SSS ports may need to be called). Gerco needs a ship designed for energy efficient operation not only in her full capacity and a specific speed, but also for an expected operational range of these parameters. - Gerco needs to know how many ports the feeder can call in one round trip, considering that the targeted ports may have limited bunkering facilities. - Gerco needs to know critical characteristics (e.g., draft limitations) and services provided by (e.g., cargo handling infrastructure) the SSS ports, which affect ship design and her manoeuvring requirements. - Gerco needs the feeder to have minimum OPEX and, besides limiting fuel cost, he also considers the potential benefits from high levels of automation. - Gerco needs the feeder to have a minimum impact on the local society of the SSS port, considering for example issues related with environmental pollution and noise while at port. - Gerco wants to explore service at SSS ports that are currently not used by cargo vessels.
UML Activity diagram:



7. Conclusions

The main goal of this deliverable was to provide the descriptions for the Use Cases of the MOSES innovations. Special focus was given, towards the direction of reflecting the interdependencies and the interrelations between the collaborating personas and their correlation with MOSES innovations. The Use Case extraction process was based on a persona-centric approach, towards defining the key personas and subsequently identifying represented scenarios, based on the personas' needs and relations.

The means used for applying this approach in practice were based on an iterative process of conducted interviews and workshops with external stakeholders, as well as on capitalising on the distinct knowledge and the diverse nature of MOSES consortium. The active enrolment of all responsible project partners was one of the major achievements of this deliverable.

The analysis made has considered and incorporated the outcomes of D2.1 'MOSES stakeholder and end-user needs', with the view to refine the initial set of user needs up to the required level of detail (via the Use Cases definition) and subsequently to provide a more detailed input to Task 2.4 'Specifications for MOSES innovations' towards facilitating the Concept of Operations (ConOps) and the system specifications for the MOSES innovations and the MOSES technical (WP3-WP6) and demonstration (WP7) WPs.

Considering all the above, 13 personas have been identified, while 12 scenarios have been described and 8 Use Cases have been defined. The description of Use Cases from this document should not be considered as a static process, but instead, it will evolve during the project, based on the technical needs in the corresponding WPs (WP3-WP6).

References

- [1] <https://www.interaction-design.org/literature/article/personas-why-and-how-you-should-use-them> (Last accessed on 04/02/2021)
- [2] Rosson and Carroll's (2002) Usability engineering: Scenario-based development of human-computer interaction [https://books.google.gr/books?hl=el&lr=&id=sRPg0IYhYFYC&oi=fnd&pg=PP2&dq=Carroll+\(Usability+Engineering,+2000\)&ots=mIEt0iUFKO&sig=jpWyABEWxpB6XchMiG20dNjnr70&redir_esc=y#v=onepage&q=Carroll%20\(Usability%20Engineering%2C%202000\)&f=false](https://books.google.gr/books?hl=el&lr=&id=sRPg0IYhYFYC&oi=fnd&pg=PP2&dq=Carroll+(Usability+Engineering,+2000)&ots=mIEt0iUFKO&sig=jpWyABEWxpB6XchMiG20dNjnr70&redir_esc=y#v=onepage&q=Carroll%20(Usability%20Engineering%2C%202000)&f=false) (Last accessed on 04/02/2021)
- [3] https://www.ivarjacobson.com/sites/default/files/field_iji_file/article/use-case_2_0_jan11.pdf (Last accessed on 04/02/2021)
- [4] S. Hosono, M. Hasegawa, T. Hara, Y. Shimomura, T. Arai, A Methodology of Persona-centric Service Design, Proceedings of the 19th CIRP Design Conference – Competitive Design, Cranfield University, 30-31 March 2009, pp541, <https://dspace.lib.cranfield.ac.uk/handle/1826/3649> (Last accessed on 04/02/2021)
- [5] Port Sustainability and Stakeholder Management in Supply Chains: A Framework on Resource Dependence Theory, Gul Denktas-Sakar, Cimen Karatas-Cetin, The Asian Journal of Shipping and Logistics, Volume 28, Issue 3, available at: <https://doi.org/10.1016/j.ajsl.2013.01.002> (Last accessed on 04/02/2021)
- [6] https://www.cbs.dk/files/cbs.dk/mapping_report_c_value_creation_1.pdf (Last accessed on 04/02/2021)
- [7] MSC.1/Circ.1604, 14 June 2019, INTERIM GUIDELINES FOR MASS TRIALS, IMO
- [8] <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx> (Last accessed on 04/02/2021)
- [9] <http://www.emsa.europa.eu/mass.html> (Last accessed on 04/02/2021)
- [10] Saffer, D. (2007). Designing for Interaction – Creating Smart Applications and Clever Devices. AIGA Design Press
- [11] Marshall, R., Cook, S., Mitchell, V., Summerskill, S., Haines, V., Maguire, M., Sims, R., Gyi, D., and Case, K. (2015). Design and evaluation: End users, user datasets and personas. Applied Ergonomics, 46 part B, pp. 311- 317. DOI:10.1016/j.apergo.2013.03.008
- [12] <https://safety4sea.com/cm-safe-mooring-key-challenges/> (Last accessed on 04/02/2021)

- [13] <https://www.interaction-design.org/literature/topics/user-scenarios> (Last accessed on 04/02/2021)
- [14] https://www.era.europa.eu/sites/default/files/activities/docs/framework_guide_overview.pdf (Last accessed on 04/02/2021)
- [15] Hosseini, A., Sahlin, T. An optimization model for management of empty containers in distribution network of a logistics company under uncertainty. *J Ind Eng Int* 15, 585–602 (2019). <https://doi.org/10.1007/s40092-018-0286-2> (Last accessed on 04/02/2021)
- [16] Optimization of Costs in Empty Container Repositioning, available at: https://www.researchgate.net/publication/336818492_Optimization_of_Costs_in_Empty_Container_Repositioning/citations (Last accessed on 04/02/2021)
- [17] Erkan et al. (2017), “An Analysis of Accidents Occurred on Tugboats”, Proceedings, Pilotage/Towage Services and Technologies Congress '17.

Acknowledgements/Credits:

Illustrations for personas 8 and 9 have been created using designed vectors made by Freepik from www.flaticon.com

Illustrations for the rest of the personas have been obtained from <https://www.shutterstock.com/home>