SEAMLESS

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D6.1 - OUTLOOK ON KEY PERFORMANCE INDICATORS FOR USE CASES

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REFERENCES TO THIS DOCUMENT – ACKNOWLEDGEMENTS

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List of Abbreviations

Abbreviation	Full Name
BB	Building Block
CBA	Cost Benefit Analysis
CLW	Can Live Without
DNL	DockNLoad
DUC	Demonstration Use Case
EC	European Commission
EEOI	Energy Efficiency Operational Indicator
EEOI	Energy Efficiency Operational Index
EU	European Union
GHG	Greenhouse Gas
GMP	Green Machinery and Propulsion
GNC	Guidance, Navigation and Control
HSEQ	Health, safety, environment, and Quality
IMO	International Maritime Organisation
IWN	Inland Waterway Navigation
IWT	Inland Waterway Transport
KPI	Key Performance Indicator
MH	Must Have
MNT	ModalNET
MO	Market Objective
MV	Modular Vessel
NH	Nice to Have
NMVOC	Non-Methane Volatile Organic Compounds
PM	Particulate Matter
ROC	Remote Operation Centre
SO	Social Objective
SPM	Smart Port Manager
SSS	Short Sea Shipping
TO	Technical Objective
TUC	Transferability Use Case

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EXECUTIVE SUMMARY

This deliverable focuses on defining Key Performance Indicators (KPIs) to determine the impact of the SEAMLESS automated waterborne service on the Short Sea Shipping and Inland Waterways logistics supply chain in terms of the economic, environmental, and societal perspectives of sustainability. Specifically, these KPIs will be used to evaluate the individual performance of the SEAMLESS Building Blocks, as well as their combined effect on the SEAMLESS service. In addition, the KPIs will be used to evaluate the achievement of the SEAMLESS objectives as described in the project's Grant Agreement.

For selecting the most suitable KPIs, a literature review was conducted on performance indicators employed by previous studies in the field of maritime logistics, supply chain management, port performance, and the Short Sea Shipping (SSS) and Inland Waterway Transport (IWT) infrastructure. The literature review was enhanced with the utilisation of the proposed KPIs that stemmed from the EC-funded projects AEGIS, AUTOSHIP and MOSES. To evaluate the identified KPIs, specific queries were formulated and circulated amongst consortium partners. By addressing these questions, it was ascertained whether a KPI is appealing for promoting the SEAMLESS service or not, while simultaneously appraising its measuring feasibility. Additionally, other criteria used for determining the KPIs relevance with the project's scope is the correlation of the indicators with the SEAMLESS Demonstration Use Cases (DUCs) and Transferability Use Cases (TUCs). The correlation among KPIs, DUCs and TUCs provides a baseline for the quantification and facilitates the comparison of the SEAMLESS solutions with other transport chains (typically road-based transport or conventional waterborne transport).

The suggested KPIs are designed to be measurable, concise, relevant to the project scope, easily understood by stakeholders, and have been classified in the following categories:

- Economic: including cost, profit, and logistical efficiency.
- Environmental: including GHG emissions and other ecological aspects.
- Social: including safety, security, and other externalities.

The KPIs will support the later studies by providing essential indicators for the subsequent socio-economic and environmental calculations in SEAMLESS. Specifically, the output of this deliverable will provide feedback both for the cost-benefit analysis performed under Task 6.2 and the societal and environmental assessments described in Task 6.3. The KPIs will also be validated through the evaluation of the SEAMLESS transferability cases required by Task 6.6. It should be noted that Task 6.1 has a relatively early deadline (i.e., December 2023) compared to the implementation period of SEAMELSS and the starting date of other tasks' dependencies. To that end, the suggested KPIs will constitute a provisional KPI register that could be revisited during the project's lifetime.

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1 INTRODUCTION

1.1 BACKGROUND

The maritime transport policy of the EU highlights the pivotal role of waterborne transport in fostering sustainable growth across Europe. The European Green Deal has set ambitious targets, aiming to reduce Greenhouse Gas (GHG) emissions by 90% by 2050. To achieve that transition to zero emissions, the EU plans to take advantage of the immense capacity of freight transport that Inland Waterways Transport (IWT) and Short-Sea Shipping (SSS) has to offer and aims to increase the freight transportation of IWT and SSS by 25% by 2030 and by 50% by 2050 (European Commission, 2020). However, the realization of these objectives has faced challenges (Psaraftis & Zis, 2021).

According to the EU Statistical Pocketbook (European Commission, 2023) from 1995 to 2021, intra-EU road transport (EU-27) in tonne-kilometres experienced a notable growth of 65.2%, surpassing the relatively slower growth rate of SSS at 38.9%. During the same period, the share of road transport increased from 47% to 54.3%, while SSS marginally decreased from 28% to 27.2%. The share of IWT declined from 5.1% to 4.0%, and the share of railway transportation decreased from 15.6% to 11.9%. Despite these shifts, the total freight increased by 43.0%.

SEAMLESS constitutes an immensely ambitious EC-funded project that has set out to address a quite broad and multidisciplinary set of problems, oriented towards contributing to the accomplishment of modal equilibrium in Europe. The project aims to develop an integrated offering comprised of a waterborne SSS and IWT shuttle service whose core enabling modules will revolve around highly automated and autonomous technologies. To that end, measuring the added value of the SEAMLESS innovations in the maritime domain is a vital process that requires a diverse (yet realistic) set of metrics.

A tool that has proven credible and reliable towards measuring performance is the use of metrics known as KPIs. KPIs represent a set of measures focusing on elements of the organisational performance that are most critical for the overall success of the project (Parmenter, 2015). Thus, several institutions and organisations responsible for the realisation of intricate and complex projects ensure their objectives are met in an efficient manner by evaluating their impact through pre-defined quantifiable KPIs.

In effect, KPIs constitute a way of managing a project through identifying growth strategies, establishing whether these strategies are effective, and maximising operational efficiency and productivity (Domínguez, Pérez, Rubio, & Zapata, 2019). It is therefore to be expected that aspects concerning the development and identification of KPIs are increasing in importance, which is also proven from their diverse scope within the business environment, such as product service (Mourtzis, Fotia, & Vlachou, 2016), supply chain network (Petersen, et al., 2016), and public transport system (Mnif, Galoui, Elkosantini, Darmoul, & Said, 2015).

Consequently, the right set of KPIs will shine light on the performance of SEAMLESS innovations. Particularly, the identified ‘‘success indicators’’ of the project will attempt to (whenever possible) quantify the added benefits related to high levels of automation, the environment, the economy, the society, and other areas related to the broad scope of SEAMLESS.

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1.2 Objectives of Work Package 6 and Task 6.1

To actively identify and elaborate on the added benefits incurred by the SEAMLESS innovations, Work Package 6 focuses on:

- Identifying and develop technical, economic, environmental, and social KPIs for evaluating the SEAMLESS building blocks.
- Analysing financial and economic aspects and assess the societal and environmental impacts within the context of the SEAMLESS Use Cases.
- Developing novel and viable business models for SSS and IWT that will be transferable throughout Europe.
- Identifying the skills and competences required to accelerate the deployment of the SEAMLESS building blocks.
- Assessing the pan-European impact and transferability potential of the fully automated SEAMLESS freight feeder loop service.

Task 6.1 aims to pinpoint KPIs that will assess the impact of the SEAMLESS service and Building Blocks during full-scale demonstrations (i.e., DUCs) and within the supply chain context as part of the evaluation of Transferability Cases (i.e., TUCs). The KPIs are anticipated to cover various criteria aspects for evaluation, including the economic metrics, environmental considerations, and social dimensions. Achieving an equilibrium among these three categories in the subsequent studies (including economic analysis in T6.2 and the social and environmental impact assessment in T6.3) is of utmost importance since if, for example, the SEAMLESS solutions are proven to incur excellent added benefits related to economic aspects, while not being viable from an environmental and/or societal standpoint, then the SEAMLESS service will also not provide any value to the waterborne transport system or the logistics supply chain. Thus, evaluating all trade-offs is rendered imperative, and this constitutes an indispensable prerequisite to achieve what is called achieving "win-win" solutions, i.e., concurrently satisfy all three KPI dimensions both individually and as a group.

1.3 Survey on Key Performance Indicators for SSS and IWT

In the context of developing autonomous solutions and technologies applicable to SSS and IWT, there have been several EC-funded projects with relevant work on mapping KPIs–three closely connected EC-funded projects are MOSES, AEGIS, and AUTOSHIP. The consortium includes partners involved in these projects ensuring synergies with them. This grants the advantage of having access to the relevant information and lessons learned from their prior experience.

MOSES (MOSES, 2023), which was finalised by the end of 2023, aimed to enhance the SSS domain of the European container supply chain by addressing the vulnerabilities and strains which relate to the operation of large container ships. To achieve this goal the project developed a series of technological innovations, including a robotic container handling system, an autonomous manoeuvring and docking scheme, and the concept of a swarm of autonomous tugboats that will be capable of independently assisting the docking operation while interfacing with a digital collaborating and matchmaking platform. To evaluate the MOSES innovations, a sustainability framework (relying on KPIs) was developed that would assess their performance and viability. The sustainability

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framework indicators were identified from the societal, economical, and environmental impact perspectives.

AEGIS (AEGIS, 2023) was completed in November 2023. During its implementation period, it strived to design a more flexible, connected, and user-centric logistics system, while improving the social an environmental impact of EU transports. The project achieved that goal by using innovations from the area of connected and automated transport, including smaller and more flexible vessel types, automated cargo handling, autonomous ships, new cargo units, and new digital technologies to regain the position that the waterborne domain traditionally had in freight transport. The AEGIS KPIs included criteria grouped under the classes of: Economic KPIs (including cost, profit, logistical efficiency), Environmental KPIs (including GHG), and social KPIs (including safety, security, externalities). The KPIs aimed to be measurable, compact, and easily understood (Zis, Psaraftis, & Reche-Vilanova, 2023).

AUTOSHIP (AUTOSHIP, 2023) was concluded in November 2023. Its objective was to operate two (2) different autonomous vessels and their required shore control and operation infrastructure, reaching and going over TRL7[1]. The developed technologies included fully autonomous navigation, self-diagnostic processes, prognostics, and operation scheduling, as well as communication technology enabling a high-level of cybersecurity while integrating the vessels into state-of-the-art digital infrastructure. The AUTOSHIP KPIs were identified for both IWT and SSS domains. The classification of their extensive list entailed societal, managerial, environmental, and financial KPIs.

Except for the research projects, several recent studies stress the importance of developing and identifying pertinent KPIs for measuring performance in a port or the IWT. For instance, a recent study (Vaggelas, 2016) attempted to evaluate port performance, efficiency, and effectiveness in ports, looking into the port user's perceptions on this matter. For this purpose, a framework was developed and included a typology of elements that captures the peculiarities of different port markets (container ports, dry bulk ports, Ro-Ro ports, etc.). The key parameters identified to shape port users' perceptions were related to several port operational aspects (i.e., availability, accessibility, connectivity, quality, and timeliness of services) and grouped under the criteria dealing with operations in the port-sea interface, the port area, and the port-land interface. Regarding the container port market, port users reported the parameters affecting cost, port operating hours, port hinterland transportation, clearance procedures and ports responsiveness as of great importance.

In the case of IWT, a Via Donau-funded research (Duldner-Borca B. v.-E., 2023) developed a method for assessing the economic benefits of resolving nautical bottlenecks on inland waterways. Identification of KPIs relevant to IWT infrastructure was vital for understanding the effects of removing nautical bottlenecks. A systematic literature review provided a list of ten KPIs clustered into: (i) IWT-related KPIs (i.e., vessel draft, transport duration, fuel consumption, transport supply and transport emissions); (ii) market-related KPIs (i.e., transport demand and modal share); and (iii) location-related KPIs (i.e., through-put and fairway depths).

[1] TRL 7, corresponding to a Technology Readiness Level, involves the demonstration of a system prototype in an operational environment.

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2 METHODOLOGY

Establishing KPIs for a project presents a significant challenge due to varying interpretations of project success among diverse stakeholders (Cox, Issa, & Aherns, 2003). The appropriate choice of KPIs is crucial not only for performance measurement but also for evaluating the proposed solutions (Bryde & Brown, 2005) in SEAMLESS. To address these challenges, the methodology applied in this task should exhibit the following characteristics (Toor & Ogunlana, 2008):

- Adopt a holistic approach.
- Incorporate direct input from partners.
- Aim for simplicity in its application.
- Display flexibility and be resilient to easily address encountered issues during implementation.

Practical experience from past EC-funded projects (similar to those mentioned in Section 1.3) has shown that the added value of establishing creative and intriguing KPIs, which are simultaneously extremely hard (or even impossible) to credibly evaluate (either qualitatively or quantitatively), is unsubstantial or insignificant. For that reason, in the context of SEAMLESS, the fundamental prerequisites of the identified set of KPIs are to be realistic, measurable, and easy to comprehend by potential stakeholders. As such, the focus will be placed on KPIs capable of showcasing the project's impact through the developed SEAMLESS concepts, innovations, and results, by employing a dependable and trustworthy approach, which will predominantly rely on scientific data, and not explicitly on conjectures.

Taking into consideration the above conditions and principles, the methodology is shown in Figure 1 and its steps are described below.

<u>Step 1: Reviewing KPIs in past projects</u>

The first step reviews previous studies and research projects assessing KPIs formulation and analysis, including those in projects AEGIS, AUTOSHIP and MOSES, which developed a set of KPIs for benchmarking automated operations and logistic processes relevant to a waterborne transport system in Europe.

<u>Step 2: Preliminary KPIs list</u>

During the second step, a preliminary list of KPIs was compiled, which reflected the scope of SEAMLESS and considered the needs of the different stakeholders affected by the project's outcomes. The focus was given on indicators that show the benefits of the SEAMLESS service. The KPIs are also required to capture the functionality of each Building Block (BB) and derived from requirements of the different operational profiles that are pertinent to SSS and IWT while considering the connectivity and functionality of each Building Block (BB). The KPIs are then classified into the following categories: economic, environmental, and social.

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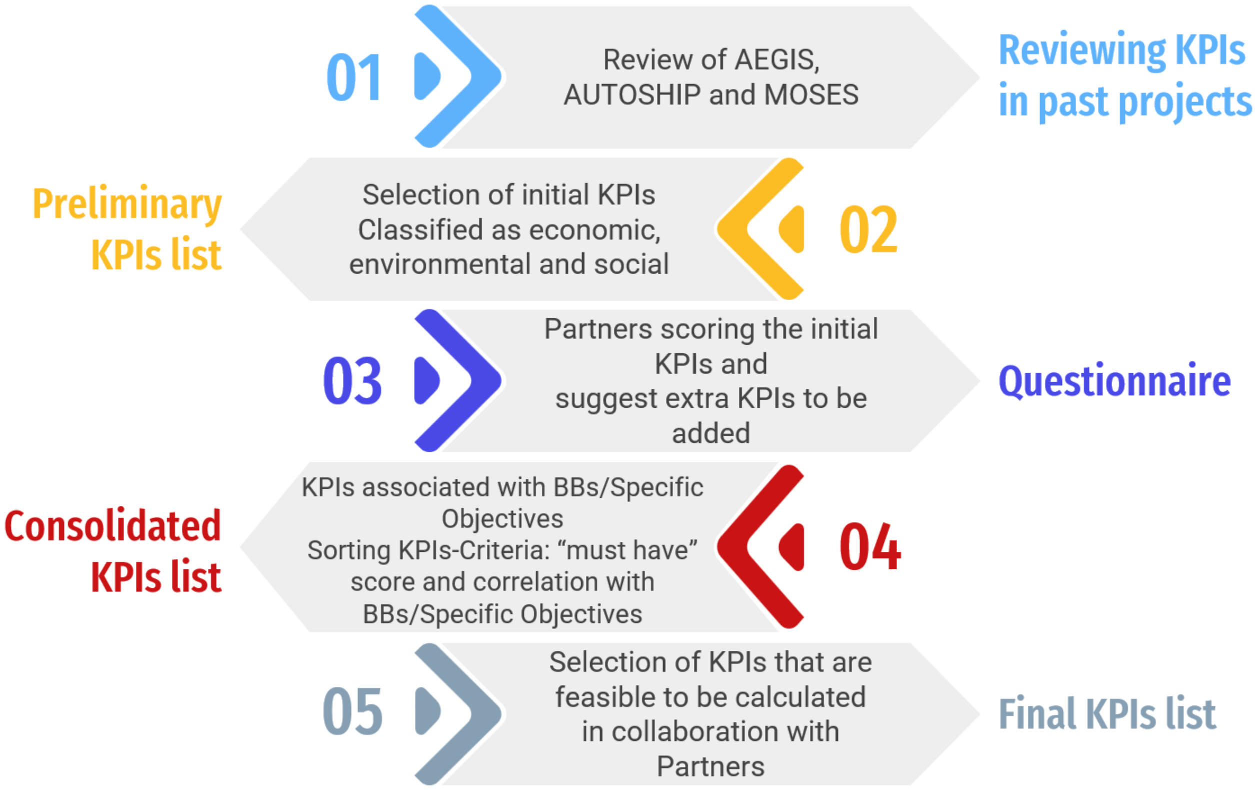

Figure 1 An overview of the methodology used to identify KPIs.

Step 3: Evaluation and additional KPIs (Questionnaire)

The aim of this step was to exploit the partners' expertise for sorting the preliminary list of KPIs. Through a structured questionnaire, the project partners rated the relevance of each KPI in the preliminary list with the SEAMLESS suggested solutions and future use cases as "must have", "nice to have" or "can live without". Through the questionnaire, partners also had the opportunity to propose additional relevant KPIs. As a result, the preliminary list of KPIs, enhanced and complemented by the partners' suggested KPIs gathered through the questionnaire, formed the extensive list of KPIs for SEAMLESS.

Step 4: Consolidated KPIs list

The KPIs included in the extensive list were correlated to the project's building blocks (see Figure 2) and the performance indicators related to the SEAMLESS specific objectives (see Table 2). The aim was to consolidate the extensive KPIs list into a shorter version based on the following criteria:

- KPI should be scored as a "must have"[2]

[2] For the additional KPIs that were not included through the questionnaire feedback, the criteria are restricted to its correlation with a building block, the SEAMLESS service, and/or specific objectives.

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- There must be a correlation between the KPI and an associated building block, SEAMLESS service and/or specific objective.

Step 5: Final KPIs list

The aim of this step was to ensure the identified KPIs can be measured during the project. All relevant partners were asked to review the consolidated list of KPIs during online workshops, where the consolidated list of KPIs was presented. Using a questionnaire that was circulated after the workshops, the partners were asked to assess the feasibility of the KPIs, in terms of data availability, quantification opportunities during the project, etc. The final list of KPIs includes those considered as viable to be evaluated either quantitatively or qualitatively.

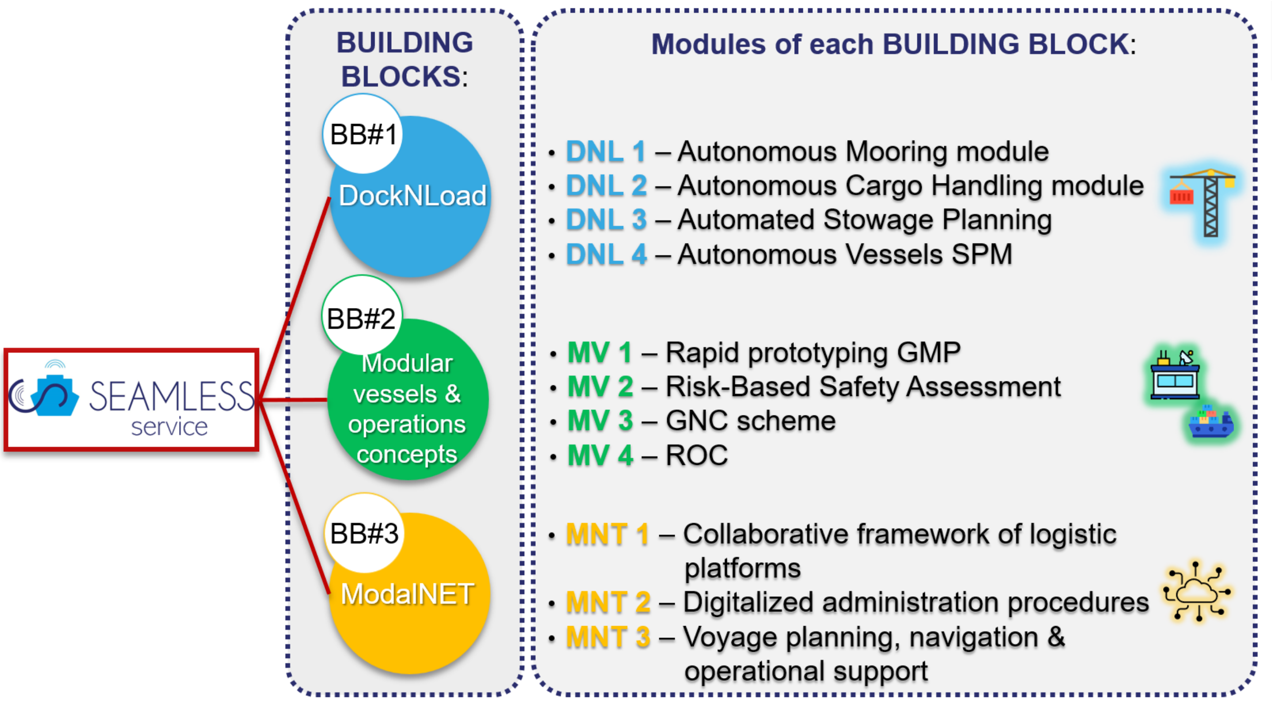

Figure 2 The SEAMLESS building blocks and the associated modules.

The final list of KPIs may be revisited during the project's implementation period as required by subsequent tasks (e.g., Task 6.2: Financial and economic analysis) and associated challenges (e.g., establishing the baseline values). As a result, several KPIs may be modified depending on the needs of the use cases and the associated BBs, whereas others may be recalibrated depending on the available operational data.

The final list of KPIs will be an interactive register of indicators which will be readily available for every partner to advise, review, update, and consolidate. Every KPI will be assigned to specific partners and correlated with the project's relevant Tasks. It should also be noted that the final KPIs list may be revisited during the project implementation as required and mandated by the project's subsequent tasks.

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3 SPECIFIC OBJECTIVES OF SEAMLESS

The primary goal of SEAMLESS is to develop and adapt missing building blocks and enablers into a fully automated, economically viable, cost-effective, and resilient waterborne freight feeder loop service for SSS and IWT. The service will be delivered 24/7 by a fleet of autonomous cargo shuttles, with humans-in-the-loop located in Remote Operation Centres (ROCs), which efficiently cooperate with automated and autonomous shore-side infrastructure and safely interact with conventional systems. The innovative concept of SEAMLESS service not only aims to improve current freight transport methods for increased cost-effectiveness; it also attempts to manage associated risks. The SEAMLESS automated technological solutions are set to mitigate the potential for human errors and reduce the risk of human injury/loss by removing human involvement from vessel mooring/docking and cargo handling processes. With the intention to optimise the cargo transport within SSS and IWT, new conceptual ship designs will be proposed to increase the maximum cargo handling weight while simultaneously reducing the vessel energy demands.

The SEAMLESS KPIs are expected to elaborate and build on the performance indicators outlined in the detailed project's objectives specified in the Grant Agreement. SEAMLESS consists of three distinct types of objectives: (i) Technical, (ii) Market, and (iii) Social as summarised in Table 1.

Table 1 Specific Objectives in SEAMLESS.

TYPE	Description	
Technical Objective (TO)	TO1	Improve cost-effectiveness and safety of highly automated and autonomous port-side infrastructure in SSS and IW ports in where autonomous vessels are calling
	TO2	Simplify the deployment requirements and reduce the investment and safety risks of fully automated waterborne transport services
	TO3	Provide full and seamless integration of the autonomous feeder system into the digital transport ecosystem and promote synchro modality
Market Objective (MO)	MO1	Develop and upscale sustainability-driven and autonomy-enabled business models for inland waterway transport and short sea shipping
Social Objective (SO)	SO1	Provide a list of recommendations and a roadmap to the legal and regulatory framework for SSS and IWT to make deployment safer and less costly and to reduce risks for early movers

Each specific objective includes various performance indicators designed to measure the progress towards achieving the objectives, as shown in Table 2.

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Table 2 Performance Indicators for SEAMLESS Specific Objectives.

SEAMLESS Specific Objectives	Description
TO1	a. Reduce time needed for berthing compared to current practices by 20%
	b. Reduce cargo handling cost by 20%
	c. Increase cargo handling service availability for small feeder ships at port by 40%
	d. Reduce waiting time for transhipment to land-based transport modes or feeder services (terminal handling time) by 30%
TO2	a. Total investment cost of autonomous vessels for SEAMLESS service not higher than comparable road system
	b. Reduce general cost and time required for approving deployment of autonomous ships by at least 75%
	c. Reduce workload for ROC operators, ships per operator > 1
	d. Reduce cost for ROC deployment for SSS and IWT applications by 40%
TO3	a. Enhance cyber-threat catalogue relevant to autonomous waterborne transport
	b. Improve the accuracy of just-in-time planning (unimodal and multimodal) by 20% compared to current practices
	c. Reduce time required for resuming feeder service operation in case of disruptions by 20%
MO1	a. Reduce the cost of waterborne feeder services for SSS and IWT by 40%
	b. Reduce time required for administrative processes in the supply chain by 60% compared to paper-based document exchanges
	c. SEAMLESS innovations transferable to at least 7 deployment scenarios
	d. Cost-Benefit ratio of the SEAMLESS innovations < 1
	e. Net Present Value (NPV) of the SEAMLESS innovations higher compared to NPV of alternative solutions
SO1	a. Publication of guidance for early movers to comply with the legal framework at least on the use case locations
	b. Identification of the top-10 legal issues to be clarified/adapted
	c. Publication of 10 specific recommendations to policymakers to improve the legal framework
	d. Publication of a risk mapping

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4 SEAMLESS KPIS LIST

The final list of KPIs for SEAMLESS was a result of two main factors: (1) the mapping of the appropriate indicators that either align with the project's objectives or evaluate the BBs' performance and (2) partners' qualitative ranking of their computing feasibility. As the ranking is based on the involved partners' knowledge, it is considered highly subjective and of a preliminary nature. Therefore, further analyses in SEAMLESS may require refining of the final list.

4.1 ECONOMIC KPIS

The economic KPIs category refers to all the SEAMLESS indicators linked to financial aspects. They are further divided into three sub-categories: cost, time and others, as presented in Table 3. The KPIs marked as "NEW" are the partners' suggested ones after the questionnaire's circulation.

4.2 ENVIRONMENTAL KPIS

The environmental KPIs category refers to all the SEAMLESS indicators that concern the environmental performance of the SEAMLESS solutions and are presented in Table 4. The KPIs marked as "NEW" are the partners' suggested ones after the questionnaire's circulation.

4.3 TABLE 1SOCIAL KPIS

The social KPIs category comprises the indicators that add value to the societal performance of the SEAMLESS service and are presented in Table 5. The KPIs marked as "NEW" are the partners' suggested ones after the questionnaire's circulation.

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Table 3 Economic KPIs included in the final list of KPIs.

Sub-category	KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
Cost[3]	**CAPEX**	€	Refers to the funds an organization allocates for the acquisition, enhancement, or maintenance of fixed assets. In SEAMLESS, these may include, for example, the investment costs associated with the autonomous vessel's concepts and the cargo handling equipment.	TO2-a MO1-d/e	All	-
	OPEX	€	Represents the costs an organization spends to run its day-to-day operations. In SEAMLESS, these may include operational costs such as crew, stores and maintenance that will be incurred whatever trade the ship is engaged in.	TO1-b MO1-d/e	All	-
	VOYEX	€	Represents the costs an organization spends due to ship's sailing or operation. In SEAMLESS, these will include costs associated with a specific voyage and include such items as fuel, port charges and canal dues.	MO1-a	-	-
	Cost per transportation unit	Total cost/TEUs or tons	Refers to the transportation cost (including CAPEX, OPEX, VOYEX, ROC costs etc.) of one cargo unit between an origin and a destination. It is calculated by dividing the	TO1-b MO1-a	All	-

[3] The cost category comprises the quantitative economic KPIs, quantified in euros (€) unless specified otherwise.

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Sub-category	KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
			sum of costs by the parcel size (Nordahl, Nesheim, & Lindstad, 2022).			
	NEW **ROC CAPEX**	€	Refer to the capital expenses of ROC.	TO2-d	BB2	MV4
	NEW **ROC OPEX**	€	Refer to the operating expenses of ROC.	TO2-d	BB2	MV4
Time[4]	**Loading time**	h	Loading time refers to the total duration of the cargo loading process on a vessel.	TO1-c	BB1	DNL2
	Discharging time	h	Unloading time refers to the total duration of the cargo discharging process from a vessel.	TO1-c	BB1	DNL2
	Sailing time	h	Sailing time refers to the total duration of the vessel voyage.	TO1-d	BB2 BB3	MV4 MNT3
	Waiting time	h	Waiting time refers to the time the cargo remains idle or is delayed, due to administrative procedures at the terminal (e.g., customs clearance), or because of other factors that may force the vessel or the cargo to be delayed.	TO1-d / TO3-b	BB1	DNL3
	Lead time	h	Lead time refers to the time the cargo is ready to be shipped until it is delivered at the final destination.	TO1-d / TO3-b	BB1	-
	Punctuality rate	% of port calls	Punctuality rate plays the role of a simple on-time performance indicator that provides	TO3-b	BB1	DNL4

[4] The time category comprises the economic KPIs that indicate the operational efficiency of the SEAMLESS solutions. These KPIs can be measured in number of hours unless specified otherwise.

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Sub-category	KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
			information concerning the mean deviation from expected arrival/departing time. It can be evaluated as a percentage of port calls where there has been a deviation from planned schedule.		BB3	MNT3
	Certificate handling	min	Refers to time spent at ports explicitly due to bureaucratic processes (e.g., formalities).	MO1-b	BB3	MNT2
	Cargo handling time	TEUs/h	Refers to the cargo's loading and discharging time plus the terminal handling time.	TO1-c	BB1	DNL2/3
	NEW **Berthing operations' time**	min	Refers to time spent to berth the ship, defined as the time period from the start of the operation till the mooring completion.	TO1-a	BB1	DNL1
	NEW **Unberthing operations' time**	min	Refers to time spent to release a ship from its moorings' facilities, allowing it to depart from berth.	TO1-a	BB1	DNL1
	NEW **Equipment utilization rate**	% of time	Refers to the percentage of time a crane is being used for cargo handling.	-	BB1	DNL2
Other	**Cargo carried**[5]	TEUs/ship[6]	Refers to the amount of cargo. It is measured in [cargo unit] per ship where	**-**	BB2	MV1

[5] Instead of "Cargo carried" KPI, we could use "Capacity utilisation" in % of ship's capacity. The "Capacity usilisation" KPI can be evaluated as the percentage of cargo a ship is capable of transporting.

[6] This is the unit of measurement applied for containerships.

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Sub-category	KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
			cargo unit depends on the selected vessel type.			
	Terminal area per cargo unit	m^2/cargo unit	The number of square meters of land needed to perform the SEAMLESS operations as function of the cargo moved. This metric will show if automated port solutions require different space in terminal to perform daily operations, compared to conventional/legacy infrastructures.	**-**	BB1	DNL1/2
	NEW **Ships per ROC operator**	#	The number of ships monitored by each ROC operator.	TO2-c	BB2	MV4
	NEW **Number of attack vectors**	#	The number of potential pathways or methods that malicious actors can use to target a system, network, or organization.	TO3-a	BB1 BB3	DNL1/2 MNT1/2/3

Table 4 Environmental KPIs included in the final list of KPIs.

KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
CO_2	kg of CO_2/ unit transported.	The total amount of CO_2 emitted.	-	BB2	MV1
NO_x	kg of NO_x/ unit transported	The total amount of NO_x emitted.	-	BB2	MV1
SO_x	kg of SO_x/ unit transported	The total amount of SO_x emitted.	-	BB2	MV1
Particulate matter	kg of PM10/ unit transported	The total amount of particulate matter emitted.	-	BB2	MV1

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KPI	Measuring unit	Description	Related		
			specific objective	BBs	BB module
Energy Efficiency Operational Indicator (EEOI)	tons of CO_2/ tons·nautical miles	The EEOI is developed by IMO for determining a ship's energy efficiency while in operation and assist shipowners and operators in building a framework for limiting or reducing emissions. This metric is an operational index created from measuring the ratio of a vessel's CO_2 emissions to a specific unit of transport work (IMO, 2009).	-	BB2	MV1
NEW **NMVOC**	tons/year	The total amount of NMVOC emitted.	-	BB2	MV1

Table 5 Social KPIs included in the final list of KPIs.

Sub-category	KPI	Measuring unit	Description	Related		
				specific objective	BBs	BB module
Safety[7]	**Removal of tasks in dangerous areas**	# of tasks or h	The number/ duration of manual tasks (e.g., cargo handling, mooring operations) that pose a risk of personnel injury.	-	BB1	DNL1/2
Work-life[8]	**Employment**	% of change	Influence on the occupational rate	-	BB2	MV4
	NEW **Operation hours per ROC**	h/year	The total amount of time during which ROC is actively engaged in monitoring and managing operations.	TO2-c	BB2	MV4

[7] The safety category comprises the social indicators related with the condition of being protected from harm or other non-undesirable outcomes, caused by non-intentional failure and intentional human actions or human behaviour.

[8] The work-life category comprises the social indicators related with the quality and conditions of work.

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Sub-category	KPI	Measuring unit	Description	Related specific objective	Related BBs	Related BB module
	NEW **Travelling time to/from work**	H	The amount of time spent to arrive from home to work facilities and vice versa.	-	BB2	MV4
	NEW **Time spent at home**	h/year	The amount of time an employee is able to stay at home on an annual basis.	-	BB2	MV4
	NEW **Number of work hours**	h/year	The amount of time an employee is on duty on an annual basis.	-	BB2	MV4
	NEW **Work hours during night/holidays**	h	Refers to the amount of working time during nighttime and official holidays.	-	BB2	MV4

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5 SUMMARY

The KPIs described in this report resulted from a series of communications and work that was carried out in cooperation with the SEAMLESS multidisciplinary consortium in the context of Task 6.1. From the methodology applied, 20 economic, 6 environmental and 1 social (in total 27) KPIs have been proposed. The SEAMLESS KPIs list was determined by following these steps:

- Define a **Preliminary KPIs List** based on previous related research work on KPIs done by relevant projects.
- Develop and circulate a **Questionnaire** for the partners to assess the relevance of KPIs to the project, as well as to suggest additional KPIs.
- Associate the extensive list of KPIs deriving from the questionnaire with the SEAMLESS BBs and Specific Objectives and sort them to keeping the ones that received an average Must Have (MH) scoring.
- Develop the **Consolidated KPIs List** and circulate it again to the partners, asking them to score the feasibility to measure the identified KPIs.
- Consider the input from the partners and develop the **Final KPIs List**.

The list of KPIs is considered to be provisional, in terms of feedback that will be provided at later stages of the project, e.g., based on the requirements stemming from the CBA (T6.2) and the TUCs evaluation (T6.6), where the exact metrics that can be quantified through the project's demonstrations, as well as the desktop studies and simulations, will be determined. Therefore, the list of KPIs outlined in this report, may be revised, and enhanced throughout the project's implementation to optimise the visibility of the expected outcomes of SEAMLESS, which in turn will maximise its Pan-European impact.

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