DigLogs

4.1.1 - SWOT on selected informatisation processes in the Programme Area

CFLI

Responsible partner: CFLI **Involved partners: All**			
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0.1	Draft 1	10/01/2020	CFLI
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Introduction

The main purpose of work package 4 is the definition of a roadmap to be used by public and private actors on the implementation of smart solutions based on the innovation selected in the framework of WP3 activities. In this stage, public and private transport stakeholders will be involved in the common processes for roadmap definition and innovation deployment.

Action 4.1 regards the delivery of specific SWOT analysis based on impact analysis drafted by PP5 – Actual during WP3; SWOT will be used as base for discussion with identified stakeholders about the detailed definition of roadmaps towards innovative solution deployment.

During WP4, project partners will enlarge the partnership to collect inputs and contributions from stakeholders, revise and integrate roadmap to obtain an effective and applicable implementation plan in a different context and for different operators.

1 About WP4 – Action 1

Action 1 is based on WP3 results and is specifically related to SWOT analysis provided with deliverables 4.1.x.

WP3 has delivered specific impact analyses about changes resulting from innovation deployment evaluating how the status quo can be affected. SWOT analyses reported in 4.1.x. deliverables take into consideration impact analysis to give details about the strengths and weaknesses of each innovation, which are more related to organizations' internal constraints, and values as well as opportunities and threats concerning external and less controllable factors.

SWOT analysis aims at improving actor's awareness about smart solution implementation repercussions on logistic processes from both strategic planning and decision-making standpoint.

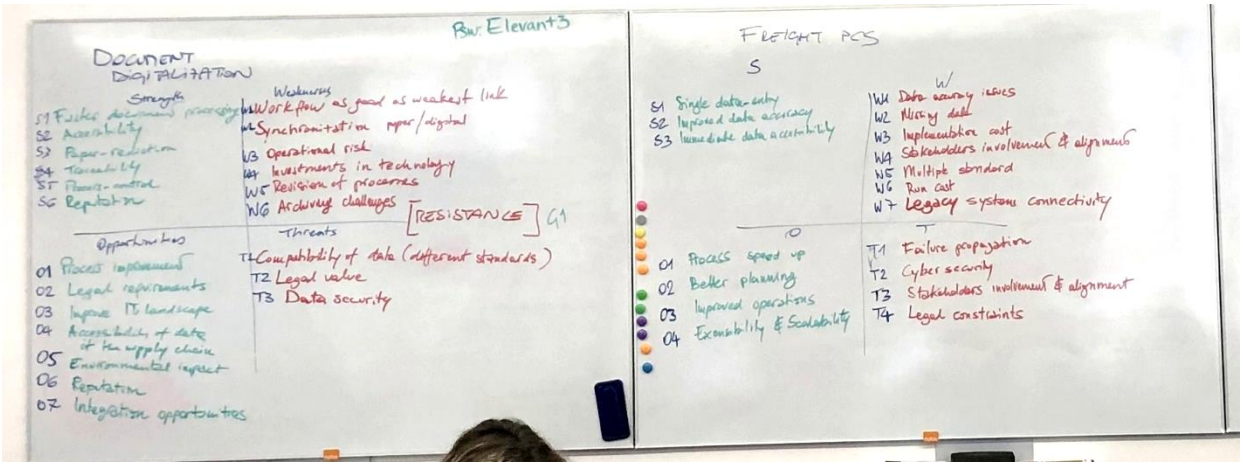
In addition to weaknesses and threats, 4.1.x deliverables report suggestions and possible remedies to avoid critical situations or mitigate negative impacts of solutions' deployment, helping to assess whether they are truly applicable in each context of the programme area.

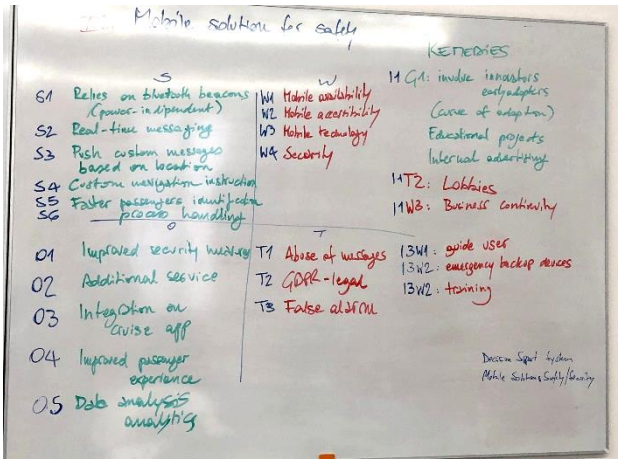
Actions 2 and 3 will go further, discussing and fine-tuning deployment roadmaps based on action 1 results, considering that an innovative solution can include one or more selected innovations.

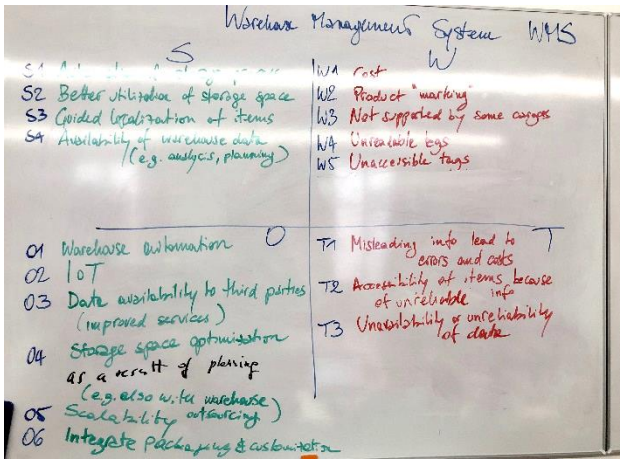
2 About information collection

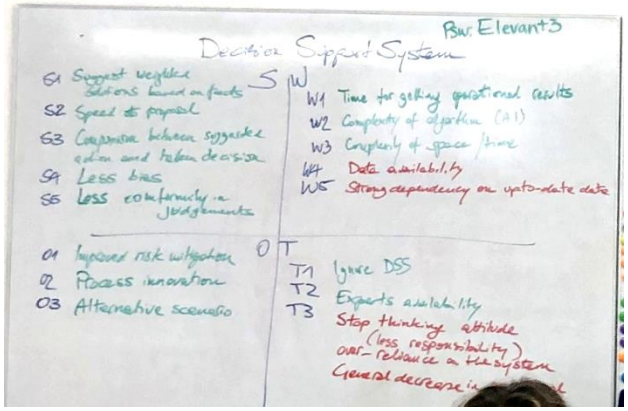
4.1.x deliverables content is the processed result of partners contributions that have been collected during the brainstorming session carried out in Trieste on November 22nd, 2019 and managed by PP2, LP and PP5.

All suggestions coming from partners have been drafted on a whiteboard and collected by PP1 – CFLI.









4.1.x deliverables also take into account the LP contribution provided on February 7th, 2020 by the report "DIGITALIZING LOGISTICS PROCESSES (DIGLOGS). SWOT analyses of selected 11 innovations" drafted by Aksentijevic Forensics and Consulting, Ltd. for University of Rijeka and revisions by PP4 University of Trieste provided on February 10th, 2020.

3 Objectives of this document

This deliverable is about SWOT analysis of the first category of innovations: informatization processes.

Chapter 4 includes five paragraphs, one for each selected innovation; each paragraph related to innovation is further structured as follows:

- **Innovation summary**: a brief description of the innovative solution
- **Needs, challenges, and opportunities**: a descriptive preview of goals, pluses, risks, and issues related to the innovation
- **SWOT matrix**: synthetic matrix diagram of SWOT analysis
- **Strengths**: strengths detailed description
- **Weaknesses**: weaknesses detailed description
- **Opportunities**: opportunities detailed description
- **Threats**: threats detailed description
- **Weakness and threats mitigation approaches**: suggested remedies and strategies to address weaknesses and threats

The last chapter of this document includes overall final considerations about innovation relationships and recurring features and issues.

4 Innovations SWOT Analysis

4.1 Document Digitalization

4.1.1 Innovation summary

Document digitalization is a base technology that brings several advantages in managing information and making processes more effective. It aims at adopting new software tools to manage document production in a dematerialized way so that search, exchange, and correlation of information become easier and faster.

Document digitalization helps also in avoiding errors, planning operations, ensuring identities and authenticity of data and information.

4.1.2 Needs, challenges and opportunities

Implementing a document digitalization solution meets the need of making more effective the management of the huge quantity of data and information produced by logistic systems, speeding up processing and exchange and reducing time and errors in information input. It also gives the opportunity to improve transparency and visibility of information to several players using the Internet, interconnect systems and planning of several services with innovative approaches.

The main challenges are about possible weak nodes in complex IT architectures that can significantly reduce positive impacts, lack of qualified personnel, inadequate hardware/software assets, standardization and security issues.

4.1.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Faster document processing, easier exchange 2. Fewer errors in data entry and exchange 3. Prevention of loss of documents 4. Visibility and transparency of data 5. Wider access to documents and data 6. Environmental impact reduction	1. Working tools upgrade/replacement 2. Workflows as good as the weakest link 3. Operational risk of disruption of work 4. A large amount of data 5. Needs qualified/trained personnel
OPPORTUNITIES	**THREATS**
1. Process improvements 2. Visibility of data for interested parties 3. Universal access and exchange of data 4. Better planning of services 5. Employees and job development	1. Compatibility of data with standards 2. Security and authorisation 3. Difficult to spot errors in data exchange 4. Shortage of skills and qualified labour force

4.1.4 Strengths

S.1. Faster document processing, easier exchange

Managing documents in digital formats speeds up production, thanks to the use of properly definite templates and redundancy elimination, as well as the exchange of information through the network. It ensures more effective business processes and, in the long-term, it brings cost savings reducing paper print, manual data entry, information redundancy, waste of time in several unnecessary steps and it increases employee productivity. Moreover, digitalization allows stakeholders to reuse data according to authorization and scope of work.

S.2. Fewer errors in data entry and exchange

Significant reduction of errors in information can be achieved properly designing document templates, providing inline data input check functions within the interfaces, adopting lists and dictionaries for the recurrent data to be entered.

S.3. Prevention of loss of documents

Storing digital copies of documents is a strong way to avoid information loss as long as an effective backup system is provided. An effective identification protocol for documents can also be used for traceability purposes.

S.4. Visibility and transparency of data

Digital documents can be made accessible through the Internet, using proper security policies and digital signature technology. This can lead to increase visibility and transparency of logistics operation towards operators and stakeholders.

S.5. Wider access to documents and data

Digital documents made accessible through the network can be used from anywhere in the world, from anyone at any time; this can generate economies since there are fewer constraints for people in collecting needed information. Digital document spread access is also a significant factor in developing process control procedures.

S.6. Environmental impact reduction

Document digitalization reduces paper use and CO2 emissions and, thus, the environmental footprints of the ports too.

4.1.5 Weaknesses

W.1. Working tools upgrade/replacement

From a technical standpoint, document digitalization means usually a major upgrade or replacement of working tools, applications and underlying infrastructure. This implies also increased costs; indeed, necessary technical modification depends on the state of existing technologies used in a company and must be adapted according to the needs of the company. Moreover, some supply chain actors may not have innovated their work processes so reducing paper may not yet led to the expected benefits.

W.2. Workflows as good as the weakest link

In a complex procedure, dematerialisation tools implementation may not give expected benefits even when just a single step remains "weak", that is it's not been optimized and/or dematerialized. The risk is not to achieve significant performance improvements even after big

investments in innovation due to the permanence of "bottlenecks". Indeed, though most documents originate electronically, several parties in port communities remain paper-based.

W.3. Operational risk of disruption of work

Digital services are always potentially at risk of interruption. Having most or even entire digitalized procedure means that, in case of service unavailability, no operation is possible. A recovery strategy for a different kind of failure is strongly needed.

W.4. Large quantities of data

Digitalizing a large number of documents means investing resources in implementing proper storage hardware and software, as well as effective security systems. These costs can be significant.

W.5. Needs qualified/trained personnel

To manage digital documents, special tools are needed as well as properly trained personnel; often, needed skills are unavailable within the existing workforce.

4.1.6 Opportunities

O.1. Process improvements

Managing digital versions of documents can improve several dependent processes and spur automation. Multiple operators can concurrently access documents or even parts of them, carrying out different tasks in parallel. Also, changes can be made dynamically, and processes will take them into account in real-time.

O.2. Visibility of data for interested parties

Some parts, or entire documents, can be made accessible to external parties that are in a way involved in the logistic processes.

O.3. Universal access and exchange of data

Digitalized documents are mostly stored using standard protocols that enable data interoperability; many processes might be improved thanks to new digital services such as the Smart Bill of Lading. Moreover, digital signature can be a key factor in improving links and

connections between supply chain and transportation services allowing better security and reliable identification of cargoes and passengers.

O.4. Better planning of services

Digital documents provide quantitative and qualitative data, relationships and identification codes that are a key factor in the development of new IT services. Digitalization of many traditional aspects of document management is underway, as companies use a variety of Big Data tools and techniques to increase the connection with suppliers, customers, partners. The digitalization of business processes and information transparency in the supply chain are the most important trends that companies will develop in the next future.

O.5. Employees and job development

The replacement of the typewriter by personal computers still required a person behind a desk, who could now offer more and better services. This relationship between technology and the labour market could be changed in our digital era. A new feature of this technological change, therefore, is that robots will not only replace muscle work but also the brain (technologically feasible and cost-efficient).

The jobs will be reshaped rather than disappear; digitalization will affect the labour markets in a way that some jobs will be replaced, some jobs will be created, and many jobs will be transformed. Digitalization may – if everything is assumed as equal – increase job turnover and, in doing so, facilitate an even more efficient division of labour within the economy. Jobs associated with unpleasant conditions such as physically demanding work may increasingly be substituted by new technologies. Digital technologies can also contribute to more flexible time management of both employers and employees.

Mobile work based on information and communication technology (ICT) may reach completely new dimensions in quantitative and qualitative terms. This means that document digitalization has the potential to offer more opportunities for participation.

4.1.7 Threats

T.1. Compatibility of data with standards

Standards are a primary condition to reach services and data compatibility. At the same time, keeping aligned generated data and evolving standards can be a real challenge. Not all documents digitalized solutions and projects follow the same standard or the same version/variant of the standard. Nevertheless, the adoption of different/outdated standards might affect the interoperability benefits.

T.2. Security and authorisation

As for most IT applications by now, handling information provided from several users means dealing with security legislation; a digital document management solution must provide robust and reliable authentication system compliant to the current legal framework.

Document digitalization allows a much easier way of handling business data, but at the same time brings new risks regarding access authorizations to document as well as attempts of forging and deletion of documents.

T.3. Difficult to spot errors in data exchange

In some cases, handling documents with digital tools can generate errors and bugs that are not easy to be detected.

T.4. Shortage of skills and qualified labour force

Necessary skills that the labour force will be needing to adapt to the new digital environment include the ability to work within the digital tools. A shortage of skills can result in resistance to change or a lack of cooperation.

4.1.8 Weakness and threats mitigation approaches

WR.1. Working tools upgrade/replacement

In some cases, the new innovative solution can be added as an additional service connected to the existing operation management solution. In these cases, the digitalized documents are a complement to the existing set of data used in hardcopies. It can also allow interfacing and transformation of data from a new, standardized format to a custom format used in legacy applications. In other cases, the best option is to entirely replace the existing operations

management applications with a new one. The implementation plan must provide a proper analysis of needed tools modifications.

WR.2. Workflows as good as the weakest link

To avoid the weakness, a proper promotion and incentive campaign to obtain acceptance from all parties are recommended. It is recommended also to deploy the innovative solution only when it's sure that all involved parties are ready to start to use it.

For all actors to be able to adapt to a 100% digital environment, they will likely need some time to perform the changes; maybe, a transition period can be planned in which companies and authorities can still use and/or fall back on paper documents if needed.

WR.3. Operational risk of disruption of work

To minimize the impact of disruption of work, a strong backup plan is recommended. To be effective, the plan must include different strategies according to the variety of disruption that can occur.

WR.4. A large amount of data

Issues related to a large amount of data can be addressed with a proper long-term plan of resources needed to set up data storage systems, processing tools, and data retention policies.

WR.5. Needs qualified/trained personnel

To effectively deploy the innovation solution, an employed personnel skill assessment is recommended. Based on the assessment result, a proper ongoing training and knowledge updating programme is recommended to be carried out; this could ensure a fast start-up and minimized failure situations, but also a help desk system and community support can be useful for this scope.

TR.1. Compatibility of data with standards

To avoid compatibility issues, continuous monitoring of changes and developments in standards is recommended. This can allow implementing corrective action beforehand.

TR.2. Security and authorisation

Security and authorisation legal framework and technologies must be properly considered from the very beginning of the innovation design stage. It can be considered to involve special professionals with proper expertise in legislation and IT security. Has to be considered that some party can take an active role in the rule creation/update process.

Security and transparency must be built in the technology and processes at all levels. It is important that the adopted solution allows easy revision trail, logging of activities and using some innovative new technologies to assure the proof of authenticity (digital signature, blockchain).

TR.3. Difficult to spot errors in data exchange

To minimize the impact of possible errors in digital data exchange, it can be considered to develop a special verification plan based on random checks, process-based strategies or ad-hoc verification software and algorithms.

TR.4. Shortage of skills and qualified labour force

If the qualified labour force is lacking, a special education and training program should be developed and provided in proper times and ways, according to the context scenario.

4.2 PCS

4.2.1 Innovation summary

Port Community System – PCS – is a public (often Internet-based) platform enabling the smart and secure exchange of information between stakeholders involved in seaport operations. It provides a Single Window environment in which report formalities, processes, and procedures can be carried on in a digital way connecting other IT systems by specific interoperable interfaces. PCS enables better harmonization of information, standardization of data flows, data centralization, redundancy reduction, easy data submission for all members of the port community. In short, a PCS can be described as a central point for an organization to deliver or receive information.

4.2.2 Needs, challenges and opportunities

Normally, adopting a PCS meets the needs of a large number of actors; it means designing a special solution that enables several existing IT tools to communicate with each other but also harmonize existing processes and procedures in the way the operators carry them out.

In developing a PCS, there are several challenges to face up but also various opportunities. Weaknesses and threats refer to a large number of IT systems and involved actors. In such a contest, standardization, connection, integration and harmonization issues may arise as well as some resistance to change the way of working. On the other hand, opportunities can arise regarding the possibility to develop new services or redesign some internal procedures more effectively.

4.2.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Single point for submission and exchange of data 2. Data standardization 3. Improved accuracy and transparency 4. Reuse of information 5. Fast and effective routing of messages 6. Faster data availability 7. Improved process efficiency	1. Dynamic changes not allowed 2. Integration difficulties 3. Multiple standards in use 4. Difficult to establish maintenance responsibilities 5. Costs increase
OPPORTUNITIES	**THREATS**
1. Redesign and optimisation of processes 2. Wider data exchange 3. Better possibility of resource planning 4. Better analytics decision-making support	1. Connectivity issues to legacy applications 2. Difficult to align all involved parties 3. Security and authorisation 4. Resistance to change 5. Failure propagation 6. Duplication of functions

4.2.4 Strengths

S.1. Single point for submission and exchange of data

Having a single interface to carry out several formalities makes the work of operators much more effective. A single connected environment also dramatically speeds up exchange operation eliminating unnecessary steps, providing a centralized and one-time storage system for documents and information of the whole port community.

PCS reduces the administrative burden imposed on the employees in a sense that it enables simplified operational data entry and processing, as well as faster and more effective data collection and exchange

S.2. Data standardization

To assure PCS effective work, data inhomogeneity must be reduced by adopting standards protocols. Standardization is often complicated but contains many advantages in the development of new services and procedures as it makes it much easier to connect different datasets.

In everyday work, reducing the data nonconformity from different platforms that are used daily by the actors in the Port Authority, PCS contributes to increase the overall effectiveness of maritime transport and ease the communication between the national bodies (Captaincy, Ministry of Finance, Ministry of the Sea, Transport, and Infrastructure, etc.) and other operators.

S.3. Improved accuracy and transparency

Normally, using (well-designed) digital interface significantly reduces input errors and strongly improves information accuracy. This is even more likely if a proper user-centered approach is adopted in application design. PCS provides significantly better quality of gathered and exchanged data, enhancing accuracy, objectivity, and reputation.

PCS provides full transparency of the cargo movement, including dangerous goods, and other notifiable cargoes, status information and control, tracking and tracing through the whole logistics chain, full range of cargo and the maritime statistics as well as fast, easy and efficient EDI information exchange. It provides also real-time information ensuring smooth data processing, elimination of paper transactions and faster cargo movement processes.

S.4. Reuse of information

PCS centralizes all port community information and enables the managing of standardized and normalized information that can be easily reused in several procedures. This does not mean duplicating information but connecting several processes with the same information that is unambiguously stored.

S.5. Fast and effective routing of messages

PCS allows interaction with Customs systems and submission of the necessary declarations. All information regarding the import, export, transhipment and transit cargo is handled electronically, substantially reducing the need for phone calls, fax, email, paper messages and personal visit transactions among the stakeholders.

S.6. Faster data availability

PCS effectively stored information using interconnected and normalized databases make it easier and faster to carry on searches with several criteria. PCS is also a web-oriented system that enables API development for new applications and tools over the Internet.

S.7. Improved process efficiency

Easy, fast and effective information access strongly improves efficiency especially on those processes in which waste of time occurred because of false data, data inaccuracy, inaccessibility or inhomogeneity. PCS enhances coordination of operations at physical, information, and financial layer since it binds together all participants in processes improves their interaction, helps to reduce logistics costs through faster information flow and cargo delivery and enable the flow of goods boosting economic growth.

PCS also strongly contribute to eliminating informal information channels.

4.2.5 Weaknesses

W.1. Dynamic changes not allowed

Normally, efficient PCS handling is based on standard protocols and interfaces that strongly limit structural changes and modifications. Sometimes the need arises for quickly change some parts of a standard procedure, but it cannot be carried out because of the intrinsic rigidity of the system.

W.2. Integration difficulties

System integration is a focus of PCS development but it's also very hard to achieve due to the wide variety and localized applications that have to be interconnected. Furthermore, there may be significative differences in governance models between PCS operating companies. Some port community members, especially small companies, may provide a lot of information without receiving value-added and decide not to integrate with the system.

W.3. Multiple standards in use

Standard protocols can be developed ad-hoc for a new PCS but sometimes some of them already exist. Often, already existing standards have more than one version so it can be difficult to harmonize their adoption and integration.

W.4. Difficult to establish maintenance responsibilities

PCS comes as a very distributed application in which several parts are deployed and hosted by more than one party. In such a scenario, ownership of maintenance costs and the responsibility for the system maintenance could be hard to establish.

W.5. Costs increase

PCS increased implementation and maintenance costs in the IT sector while most benefits can only be realized in the long run.

4.2.6 Opportunities

O.1. Redesign and optimisation of processes

PCS enables to better organize and manage data and information, but especially to correlate one to each other documents and datasets, so that many opportunities can arise about the possibility to speed-up processes, develop new services or redesign some internal procedures more effectively. Indeed, PCS represents a useful and effective platform for messaging, transformation, notification and other management of data workflows that can be used as a business monitoring tool to allows checking the regular execution of processes, data quality and possible errors in other subsystems. PCSs could also extend parties' service portfolio and further facilitate collaborative planning and inter-organizational data processing both for port and hinterland companies. Redesign and optimization can include Blockchain technology leading to a multi-purpose more secure and reliable digital platform.

O.2. Wider data exchange

Since PCS is an Internet-based platform and provides data standardization and harmonization, data exchange with organisations and partners outside the port community, or even other port communities, becomes very much easier. Benefits and advantages of spreading connectivity and data exchange can also arise regarding several processes and procedures related to the wider logistics chain. PCS can be integrated into an exchange platform that links different applications and systems, for example between operations management applications in companies and the national Single Window platform.

O.3. Better possibility of resource planning

Resource planning is for some parts based on estimated or subjective information; PCS makes available more objective data that can be useful in supporting decision-making about resource allocation.

O.4. Better analytics and decision-making support

Standardized information enables quantitative and qualitative data extraction and transformation for analytics and reporting that is very useful to support decision-making processes.

4.2.7 Threats

T.1. Connectivity issues to legacy application

Developing a PCS platform means establishing connections between several data management systems and applications; this can be a hard issue when many of them are legacy data or legacy applications due to the lack of openness and documentation.

Another threat might come from multi-national logistics providers using powerful IT systems that can drive-out PCSs from the market.

T.2. Difficulty to align all involved parties

Dealing with many actors always means to harmonize visions and methods. Difficulties can be related to both the number of situations to manage and each party's willingness to cooperate. In some cases, PCS comes as “localized solutions” and it may reduce the willingness of some port community members to adopt them.

T.3. Security and authorisation

System integration in PCS means spending specific effort in addressing security and authorization issues at a technological level. Security functions are targeted to ensure protection from data loss and hacking while authorisation systems (e.g. Single Sign-On, Digital Identity, etc.) are more related to ensure user identification across processes and applications.

Sometimes, involved parties are not ready to submit sensitive information in a proper way, basically due to the non-implementation of available up-to-date and advanced security solutions.

T.4. Resistance to change

PCS benefits are mostly uneven distributed and can be realized only in the long run. Some companies provide a lot of information without receiving value-added, so port community members might decide not to cooperate. This is especially relevant for small companies and may prevent the development of advanced technological infrastructure.

The use of the system is basically non-mandatory, so resistance to change tools and way of work can arise from a whole party, some internal departments or from single operators. It has to be differently addressed depending on whether it comes from a decision-making level instead of an operational level.

A reason for resistance to change by port community members might be the scepticism regarding data security while another possible can be the fundamental difference in governance models across operating companies.

From a more technical standpoint, sometimes, resistance to change is more related to the agreement in adopting widely accepted standards and integrate them into procedures and applications.

T.5. Failure propagation

Having several interconnected IT systems can cause error/failure propagation from starting nodes down to the following and amplify the negative effects of each issue. Mistakes in data inputs can also cause mismatching between documents and datasets where joining data keys are wrong or missing.

T.6. Duplication of functions

If not well designed, a new PCS might duplicate functions that already exist in one or more sub-systems to be connected.

4.2.8 Weakness and threats mitigation approaches

WR.1. Dynamic changes not allowed

The complexity of a system like PCSs usually does not allow many variations in running built-in function because of low-level standards and data structures implementation. This means that there is a basic rigidity that can block processes when some not expected external changes occur. In this case, the need arises to modify the platform to accomplish the new scenario, so an effective process ongoing monitoring is recommended to early notify the need for intervention.

WR.2. Integration difficulties

In ICT, integration issues are as big as the number of sub-systems that must be interconnected; PCSs are very representative of this. This basically means that the design stage is crucial, so it is strongly recommended to start with a careful analysis stage to deeply identify goals and requirements, followed by a planning stage related to technical aspects and cost estimation.

In order to minimize integration complexity, a PCS should not duplicate functions that are already existent in other systems, but rather focus on general operational and link processes.

WR.3. Multiple standards in use

Many applications and systems that have to be integrated into PCSs are based on third-party defined standards about data and functions. Most standard definitions are released in different versions over time causing some issues when an ICT system is upgraded applying a new version of a standard needed to connect to another system that uses the previous version. When planning to adopt a standard, it is recommended to define a special strategy to manage needed upgrade stages ensuring enough flexibility not to disrupt processes.

WR.4. Difficult to establish maintenance responsibilities

In ICT implementation and utilization, maintenance is mostly underestimated. Apart from costs matter, there can be a crucial issue regarding responsibilities attribution, basically because a PCS is a "distributed system". Responsibility attribution must be clearly defined before launching PCS, regarding both legal terms and costs sharing. About this matter, involving parties from the earlier design stages can be an effective way to establish relationships and share permissions to exchange data and documents.

WR.5. Costs increase

Necessary resources for PCS implementation must be carefully estimated at the design stage, then proper found raising strategies must be undertaken.

TR.1. Connectivity issues to legacy application

To proper interface PCS to the third-party legacy application, an implementation plan must be developed, basically to assess whether it is feasible/more cost-effective to develop a custom interface or to modernize/upgrade the legacy application.

TR.2. Difficulty to align all involved parties

Aligning visons and methods of all parties is probably the biggest weakness in implementing a PCS, mainly due to a large number of involved actors. All parties must be involved from the beginning at least in designing the overall project of the PCS and contributes and results have to be effectively disseminated with a proper scheduling program. Specific education and training can be carried out from the earlier stages, even during the system design stage, to culturally and technically introduce operators and decision-makers to the new ways of working; this can be also done by carrying out workshops and developing and prototyping demo applications. Some actions aiming to increase motivation in adopting the new platform can be planned and done, also by giving incentives and fulfilling special agreements between parties.

TR.3. Security and authorisation

To ensure the highest level of security, first, an accurate assessment of existing application weaknesses must be done. Second, it is recommended to carry out deep analysis and state-of-the-art of digital security and authentication technologies, in order to properly design the overall

security ecosystem that can ensure the best level of security for the different connected sub-system.

TR.4. Resistance to change

To get rid of resistance to change in adopting a PCS it is important to well communicate goals, give visibility of benefits, listen and include user opinions and contributions, with special attention to small parties that usually own particular needs. To collect contributions, different tools and techniques can be used, such as surveys, workshops, focus groups, training programs, etc., while to communicate goals and benefits, special events can be periodically held to involve all parties and encourage them to exchange experience. It is recommended to develop different strategies and/or action plans for executive and decision-making levels focusing on the specific roles of each stake.

Special workgroups can be formed to deepen special issues, such as technical, legal or business ones.

TR.5. Hard to agree on widely accepted standards

See TR.4 for strategies and actions about resistance to change, that can be useful also to get the agreement in adopting widely accepted standards.

TR.6. Duplication of functions

To avoid duplication of existing functions, new PCSs or even PCSs' integration, the design of new platforms or new functions must be supported by a detailed assessment of existing applications among port community members.

4.3 Mobile solutions for Safety / Security

4.3.1 Innovation summary

A Mobile solution for Safety / Security is an innovation especially thought for a large passenger ship operational scenario in case of fire/flooding emergencies. In this scenario, after a casualty, ship abandonment can be required. Hence, during evacuation procedure passengers need to be guided to the safe area and then to lifeboats.

The innovation is a smart mobile solution based on short range RF communication and location-based services that help passengers and crew during safety and security procedures in getting the right instructions and useful information to shorten times of security procedure, avoid mistakes and improve communication, notification, and organization.

4.3.2 Needs, challenges and opportunities

The innovation is basically an anonymized identification and tracking system that automates information broadcast in a fast and direct way, easing passengers and crew to act properly during emergencies when usually accessing information is very difficult. Main challenges are related to the radio frequency coverage limitations, the issues about security and acceptance in the use of personal devices for such kind of application.

The solution implementation has a low level of complexity; the relative high feasibility highlights several opportunities in developing additional commercial, information and management services based on the below IT platform.

4.3.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Effective passengers identification 2. Effective information sharing in emergencies 3. Better authorisation token for access/credentials 4. Possibility of location-based services 5. Faster process handling	1. Hard to reach acceptance in apps utilization 2. Location-related operational limitations 3. Applicability on personal/private devices
OPPORTUNITIES	**THREATS**
1. Additional commercial services implementation 2. Additional information/services for passengers 3. Data analysis for process optimization	1. Complex security solutions 2. Privacy and GDPR compliance 3. Too much reliance on technologies

4.3.4 Strengths

S.1. Effective passengers identification

The solution could be based on Bluetooth Low Energy technology (e.g. beacons) that doesn't need any infrastructure neither for power supply nor for RF communication and enable fast and secure identification and location of users in a restricted/indoor area. Location can be used both to manage the crowd or to find a user by another user.

S.2. Effective information sharing in emergencies

Spread installation of a mobile application enables faster and better information sharing between all connected users during emergencies, push notifications and location-related alerts. Moreover, the crew can easily collect information and transmit specific instructions to connected users; indeed, the system can disseminate information to any passenger and crew member, but also passengers could inform the crew of a potentially dangerous situation regarding safety issues and receive instructions. Furthermore, the device owner can store important information for first responders and hospital staff, helpful during emergencies, such as contacts, insurance information, doctor information, medical condition, etc.

S.3. Better authorisation token for access/credentials

The identification system can be used as a digital token to access several services such as entering in special rooms, activating machines, accessing online services and others. Indeed, with the help of technologies such as biometrics (e.g. fingerprint/iris/facial recognition) or wearable devices, passengers and crew can be authorized for access to cabins, restricted areas, etc. Similar results can be obtained also with the usage of a dedicated mobile application. Because of the widespread usage of the smartphone by passengers, this solution can be easily implemented and allows also better customer service and user experience

S.4. Possibility of location-based services

Triangulation between beacons enables indoor/short-range positioning. It's a relatively low-cost technology and it allows any mobile device to send its location to a centralized system. A centralized platform can implement both passenger services management function for crew members. Mobile apps can be developed to easily identify unauthorized access to restricted areas, to guide people during evacuation procedures and/or to communicate to the crew in a potentially dangerous situation, resulting in a more rapid reaction.

S.5. Faster process handling

The first and most important process supported by the fast and secure automatic identification is probably the boarding process that can virtually be carried out without stopping passengers during the pathway.

4.3.5 Weaknesses

W.1. Hard to reach acceptance in apps utilization

Not all passengers will accept to install and use a new mobile-APP on their smartphone, or even doesn't own a smartphone. Some users might not believe in the security tool because of concerns about its privacy or its effectiveness, causing low adoption rates.

W.2. Location-related operational limitations

Indoor positioning can provide low-accuracy data in certain conditions and/or certain areas. Moreover, passengers might not carry their devices all-time, providing to the centralised system misleading information about their current position. During emergencies, all communication systems may also become unavailable, meaning the notification system can't be relied on.

W.3. Applicability on personal/private devices

Some personal devices could not be compliant with the application requirements due to hardware or software limitations.

4.3.6 Opportunities

O.1. Additional commercial services implementation

The mobile APP can be used for commercial purposes (e.g. payments, location-related adverts). Consider that many cruise companies already encourage the usage of mobile applications for commercial purposes (e.g. book cruises/excursions, schedule activities onboard, commercial information, etc.).

O.2. Additional information/services for passengers

A smart mobile platform is an enabling condition in the development of additional information services for passengers, such as tourist or commercial applications and tools. For example, one of the most popular mobile-based IT solution is the recommendation system which is a platform

that stores information about tourist's profile and preferences and performs a time/spatial match with available opportunities, events, locations and other attractions sending real-time push messages to help visiting or suggest activities to users during the tour. Other services can be implemented through partnerships between ship operators and mainland companies for commercial purposes.

O.3. Data analysis for process optimization

The main process optimization is probably the evacuation time reduction in case of emergency (consider also the opportunity to base the solution on the eVACUATE project founded by the European Union). Anyway, this is a basic real-time optimization; many other analyses could be based on data post-processing aiming to further optimize some safety procedures or even to improve passenger user-experience, provided that passenger privacy is respected.

Data analysis and software development can lead also to the creation of opportunities for new jobs and collaboration with companies, professionals, and researchers in marine engineering regarding system development and maintenance, information technology and automation fields.

4.3.7 Threats

T.1. Complex security solutions

Considering a large number of distributed devices needed for the system implementation and the nature of handled information (localisation), security can be a big issue. Moreover, mobile apps may crash or freeze due to a bug and not work properly during an emergency.

Dynamic routing engines are not so easy to implement due to many data sources and hardware components to be integrated as well as possible changing conditions during emergencies. A system that provides wrong routing information might be a very critical issue.

T.2. Privacy and GDPR compliance

The usage of the app should be transparent towards passengers and according to GDPR and other privacy-related requirements. Also sharing location may be an issue so it may be necessary to find a balance between duty of care and privacy.

T.3. Too much reliance on technologies

Overreliance on technology in case of emergency can sometimes lead to not doing the necessary in-place checks. In an emergency situation, the system might not be able to dynamically provide information according to the user and/or environmental features, exposing users to potential hazards.

4.3.8 Weakness and threats mitigation approaches

WR.1. Hard to reach acceptance in apps utilization

To enable basic services also for users that don't use the mobile solution, an alternative procedure must be designed and implemented. It could be based on the utilization of special portable devices provided by the crew and/or fixed devices installed onboard. Moreover, some standard backup procedures can be put in place to deal with passengers devoid of a portable device.

WR.2. Location-related operational limitations

To properly ensure services and process execution, the system must implement specific workaround algorithms, functions or strategies.

WR.3. Applicability on personal/private devices

To enable basic services also for users that cannot install the mobile solution, an alternative procedure must be provided. As for WR.1, it could be based on the utilization of special portable devices provided by the crew and/or fixed devices installed onboard or on other standard backup procedures.

TR.1. Complex security solutions

Security measures must be properly implemented, and they must be temper-proof. Both software-based solutions (e.g. location monitoring and warning) and hardware-based solution (e.g. anti-theft / manumission sensors) can be assessed.

TR.2. Privacy and GDPR compliance

No additional acquisition, storage, and utilization of passengers' data can be done without their consent. The consent agreement must be designed as a fundamental part of the application.

TR.3. Too much reliance on technologies

To avoid excessive reliance on technology systems, periodic simulation of emergencies and system checks should be scheduled and performed. Moreover, periodic drills should be performed related to backup procedures to be applied in case of system failure.

4.4 Warehouse Management Systems (WMS)

4.4.1 Innovation summary

Warehouse Management System (WMS) is a software solution aimed at supporting and optimizing warehouse and distribution center management. WMS provides special functions to facilitate management and operations planning, organizing, staffing, directing, freight storage and handling and controlling the utilization of available resources.

WMS is already employed in many port communities, anyway, an innovative system more tightly connected to all other information systems greatly benefits from the feeding of real-time data and estimation of goods movement and provides new types of optimization thanks to the integration of sensors, IoT devices and new generation of processing algorithms (e.g. AI).

4.4.2 Needs, challenges and opportunities

The adoption of a new generation WMS is mainly related to the need to better automate and optimize storage processes and spaces, and it gives several opportunities in integration with other IT systems and the application in those planning processes that can better benefit from logged data post-processing.

Main challenges are related to the risk of lack of data or low-quality data feeding, weaknesses in storage items tagging systems, standardization, and unification of identification systems between shippers and operators as well as the investment cost in technological assets.

4.4.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Increased productivity and costs reduction 2. Automation of storage processes 3. Better utilisation of storage area space 4. Packages positioning optimization	1. Overall implementation complexity 2. Operations too dependent on system quality 3. Storage identification virtually tricky 4. Possible identification tag reading issues 5. Investments in technologies 6. Need for specialized expertise
OPPORTUNITIES	**THREATS**
1. System and Process Integration 2. Cargo tracking IoT integration 3. Loading/Unloading planning improvement	1. Lack of information negative repercussions 2. Hard ID tags standardization for all shippers 3. Different response times of logistic operators

4.4.4 Strengths

S.1. Increased productivity and costs reduction

WMS can reduce operating costs by increasing warehouse productivity, especially in the long-term, reduce mistakes and help to immediately identify errors, decrease processing and document collecting time, improve data communication and exchange. Moreover, it will result in a reduction in paper usage and an increase in personnel productivity, improved security, supplier relationships, and communication.

Adopting cloud-based solutions, there might also be a cost reduction in hardware/software maintenance and database administrators.

S.2. Automation of storage processes

WMS provides algorithms and functions that directly support operators in finding the best items allocation and storage space usage, eliminating several downtime steps. Some specialized warehouse areas can include ASRS (automated search and retrieval systems) unmanned solutions. Orders can even come directly from the ERP (Enterprise resource planning) software to the WMS.

S.3. Better utilisation of storage area space

WMS helps operators to best allocate items and reduce unused warehouse space. The system can offer different types of optimization, such as minimum time for access and manipulation of goods or minimum space used in the warehouse facility. It can suggest strategies to shorten the manipulation time for example by grouping the cargo based on the next destination, next transport and by customer.

S.4. Packages positioning optimization

The positioning of the packages is optimized according to the warehouse dimension and shape, thus loading/unloading operations are speeded-up.

WMS also leads to the reduction or elimination of paper documents because warehouse personnel doesn't have to spend time reading or handling paper, data entering or thinking about where to go.

4.4.5 Weaknesses

W.1. Operations too dependent on system quality

Under WMS, warehouse operations are heavily dependent on the quality of information about arrival/stay/departure of goods and the overall system efficiency. The expected benefits will depend on the level of maturity of employed WMS system, the level of automation, on the integration with additional information sources and specifics for handling different types of goods (packages, pallets, cars, cars, etc.). Low data quality or spot system failures can strongly affect operational flow.

W.2. Storage identification virtually tricky

Using a WMS means to mark all storage items with identification tags, that can be not so easy to implement.

W.3. Possible identification tags reading issues

Access information tags on items may be hard; information tags could also wear out during transportation.

W.4. Investments in technologies

Costs of technologies in WMS implementation, maintenance and control may be significant, especially for small communities. Especially during initial stages, the cost of the devices used to automate the workflow could be significant, just as the training and software needed to operate these devices might exceed the price of the devices.

System overall implementation means that there will be the need to rearrange several warehouses, implement new procedures and controls, improve data and hardware maintenance and establish additional steps in receipt and picking process, which could be a real issue.

W.5. Need for special expertise

Special expert knowledge may be needed to configure maximum benefit from WMS. Probably low-level job positions will be reduced since the WMS will make its own decisions and instruct operators.

From an organizational standpoint, the traditional freight-forwarder job becomes process-oriented and somehow more like the manufacturing industry. Manufacturers and distributors will keep moving faster, so logistic operators will also need to do the same.

4.4.6 Opportunities

O.1. System and Process Integration

WMS offers several integration possibilities with other parts of the logistic process: at least with arrival-departure timing.

System Integration has also some special technological matters related to WMS 4.0 that is often a web cloud-based interface, it can be accessed anywhere from numerous devices and, therefore, it's independent of the physical warehouse facility. Typical specialized devices are barcode readers including pick-to-light (with light indicating the items to select) and "voice picking" (voice instructions through headphones). WMS 4.0 also allows packing, end-of-line customization, e-commerce distribution and other integrations with web-oriented services.

O.2. Cargo tracking IoT integration

With the use of innovative sensor technology, the smart WMS system can automatically track the location of the cargo and allow automatic and semi-automatic movement, check-in/check-

out, internal re-optimization of space and other activities that can lead to the desired goals. The use of IoT sensors can also allow better planning based on post-processed collected routing data.

Movement automation and robotization can improve staff productivity and reduce the risk of workplace injuries helping employees in reaching high shelves (e.g. using drones, automatic guided vehicles, IoT devices) instantly scanning items, recording locations, theft alerting and monitoring various kind of activities.

O.3. Loading/Unloading planning improvement

WMS provides plenty of data that can be post-processed for better planning ships, trains, trucks loading and unloading operations and provide better data visibility for all parties of the port community contributing to traceability of status of the cargo. A WMS system that is efficiently connected to other port and logistic chain management applications can result in the storage strategy of goods that requires minimum necessary storage manipulation.

Smart warehouse technologies help also to automate repetitive assignments and allocate the workforce more efficiently. Furthermore, using IoT devices, store managers will be able to reduce order inaccuracies and inventory damage.

4.4.7 Threats

T.1. Lack of information negative repercussions

If data about cargoes is unavailable or available too late during the process, WMS cannot include this information in the planning process as it can negatively affect the warehouse performance and later stages of logistic processes. Lack of or late information about the arrival/departure of cargo can have a multiplicative negative effect on other logistic steps.

T.2. Hard ID tags standardization for all shippers

It may be quite hard to widely apply standards in ID tags for items marking by all the involved shippers.

T.3. Different response times of logistic operators

Having too much difference in adaptation times to smart solutions implementation may diminish the benefits of technology-based innovation strategies. Also, logistics operators may not be as

quick to respond as the manufacturing and distribution industry, especially for small-scale companies and operators.

4.4.8 Weakness and threats mitigation approaches

WR.1. Operations too dependent on system quality

To avoid poor benefits and low performances by WMS it is recommended to make a detailed implementation program and simulation of major processes and function by running prototypes with samples of real data.

WR.2. Storage identification virtually tricky

Before choosing a smart solution for item marking, it is recommended to make a comparative analysis of the most suitable alternatives and implementation assessment related to the application context.

WR.3. Possible identification tag reading issues

With reference to WR.2, a specific analysis of case studies can help to assess the strength and weaknesses of each marking technology.

WR.4. Investments in technologies

We should consider that what represents a risk for somebody may be an opportunity for somebody else; avoiding the risk of making an investment could become a future risk of losing market in favour of competitors who instead already made that investment. That said, a cost-benefit analysis of a technology solution should include possible additional costs related to loss of market share caused by competitors using more advanced IT solutions.

WR.5. Need for specialized expertise

Higher-level positions will be needed in order to develop strategies and deal with a more sophisticated system than before, so it is essential to develop a recruitment plan combined with a proper training program.

To face the evolution of logistics operators' way of work, a reorganization plan is fundamental and recommended.

TR.1. Lack of information negative repercussions

Likewise of what described in WR.1, running simulations and/or prototypes based on sample data should be an effective way to assess negative repercussions caused by system weaknesses, even those related to lack of information.

TR.2. Hard ID tags standardization for all shippers

Standard acceptance and implementation by many parties may be a long-time process, so it is recommended to carefully plan the steps to be taken and the implementation times, involving all actors from the beginning, to anticipate the main solution deployment.

TR.3. Different response times of logistic operators

Likewise of TR.2, different response times of external parties should be managed to carry out a participatory process aimed at harmonizing times and methods and estimate the overall time to reach an optimal stage for further implementations.

4.5 Decision Support Systems (DSS)

4.5.1 Innovation summary

A Decision Support System is a software solution capable to collect data from several sources and to provide correlation, extraction, and synthesis of information in a way that can support decision-making. Typical front-end tools of DSSs provide effective interactive visualizations to help decision-makers reducing subjective analysis and interpretation errors during planning processes.

The back-end asset of a DSS usually embed advanced tools and uses innovative techniques such as Extract-Transform-Load (ETL), Big Data Analysis, Machine Learning to gain the best value from digital data correlation.

4.5.2 Needs, challenges and opportunities

The will to implement a DSS usually comes from the need to make complex decisions with more objectivity, to assess scenarios and to be more time/cost-effective in planning processes taking

advantage of the plenty of available digital data and processing tools and techniques. A DSS is usually a software solution for which System and Data Integration is needed with related investment costs that can be significant; moreover, implementing the system is not without risks and possible issues basically related to the difficult to define and set up custom algorithms, to integrate results in current processes and to obtain acceptance from all actors and parties.

4.5.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. More objectivity in business decisions 2. Alternative scenarios assessment 3. Time-effective decision process 4. Decision errors reduction 5. Machine Learning implementation	1. High investments in technologies 2. Little effectiveness in restricted time situations 3. Difficulty in result interpretation 4. Lack of technology knowledge 5. Employees' resistance to change
OPPORTUNITIES	**THREATS**
1. Data correlation 2. Innovative processes based on real-time data 3. Better risk mitigation	1. Resistance in acceptance by decision-makers 2. Algorithms development and maintenance 3. Difficulty in operational processes integration 4. Lack of qualified labour force

4.5.4 Strengths

S.1. More objectivity in business decisions

Basically, DSS provides useful information for business decisions based on data rather than subjective interpretation. This leads to a general improvement of planning and operational effectiveness, reduction of errors, long-term productivity increase, and cost savings.

DSS can improve communication and collaboration among decision-makers, encouraging fact-based decision making through improved data accessibility. It can also promote the learning of new concepts and the development of a better factual understanding of the business among and decision-makers as well as foster the training of new employees.

S.2. Alternative scenarios assessment

A typical DSS solution provides special tools to design different scenarios based on multiple criteria and to compare possible alternatives to a problem solution. Those are usually weighted, quantity-based algorithms, on purpose to dynamically modify parameters and assess advantages and disadvantages between different actions.

S.3. Time-effective decision process

Since it is based on data and many sources, DSS reduces decision cycle time especially when the same assessment has to be done recursively on time.

S.4. Decision errors reduction

Since in many complex situations is very hard to make interpretation of phenomena, DSS may allow eliminating most of the errors based on subjective wrong assumptions. Support in decision-making processes is more effective using DSS basically because of quantitative and real-time data availability.

S.5. Machine learning implementation

A permanent connection with many data sources makes a DSS capable to embed a Machine Learning engine and better help in analysing complex events and conditions.

4.5.5 Weaknesses

W.1. High investments in technologies

The cost of decision-making decreases once a Decision Support System is installed. But the development and implementation of a DSS require a huge monetary investment; moreover, customization and training may result in higher costs too.

W.2. Little effectiveness in restricted time situations

Depending on the use case, there may be restricted time available to get decision suggestions from DSS. There may be limited capacity to prepare correct/relevant suggestions in a timely manner. This is particularly important if DSS is intended to support operational processes that have limited run time (e.g. emergency reaction).

W.3. Difficulty in results interpretation

A Decision Support System mainly relies on quantitative data, consequently, it may be difficult to analyse intangible or indefinable data. When values cannot be specific and quantitatively defined, a DSS may quantify some of these aspects but the result may be difficult to be understood or considered by decision-makers. It may be also difficult for decision-makers to define how to consider DSS results making the final decision.

On the other hand, the DSS might strengthen the rational perspective so much as to cause excessive emphasis on the decision-making process.

W.4. Lack of technology knowledge

Although Decision Support Systems have become much simpler over the years, many decision-makers may find it difficult to use. Lack of technological knowledge remains an issue.

W.5. Employees' resistance to change

In some cases, employees might resist change and accept to rely on a new DSS due to doubts or disbelief about tools effectiveness or lack of cooperation attitude.

4.5.6 Opportunities

O.1. Data correlation

The feature of DSS to interconnect several data sources can be extended to the context outside the port community area, involving other parties working on maritime and logistic processes.

IoT data will become extremely helpful in improving services as well as in helping to identify supply gaps and analyse unmet demands. Data generated by embedded sensors will dramatically increase and Big data and analytics will gain importance in the field of intelligence, insight and of real-time basis decision processes.

O.2. Innovative processes based on real-time data

DSS makes possible to design innovative tools based on real-time data analysis to support decision processes, also applying techniques like Big Data Analysis, Machine Learning, GPS route planning, and other new methods.

Onboard ship DSS can also be developed and implemented so that, during operation, data measured from different sensors and sources (e.g., weather, routes, operational constraints) can help the operator to operate with less energy consumption.

O.3. Better risk mitigation

DSS provides effective statistical-based estimation tools that can be used to mitigate risks in port community activities. For example, the system could bring together European and international evidence on accidents and injuries causes, suggesting links between those risk factors and the respective countermeasures.

4.5.7 Threats

T.1. Resistance in acceptance by decision-makers

Decision-makers may have difficulties to understand how to use, be overloaded with information or undervalue DSS outputs in their own processes, so the acceptance to adopt a new technological solution may be a critical issue.

T.2. Algorithm development and maintenance

Algorithm and DSS "intelligence" must be kept aligned with processes needs; developing, confirming and maintaining DSS functions to obtain expected results may be both a technical and economic issue. DSSs will create new opportunities for research institutions and software houses that might increase the number of IT solutions to be available on the market, requiring the definition of new algorithms and mathematical models.

T.3. Difficulty in operational processes integration

It is difficult to apply DSS to operational processes; it is more natural in strategic decision-making. DSS will affect and change mostly management (operational and strategic) decisions, but not directly and immediately the operational processes.

T.4. Lack of qualified labour force

In order to design and implement a new DSS, in-depth technical knowledge is required, in particular, software developers with high-level technical knowledge; low-skilled professionals will not be able to manage the systems.

4.5.8 Weakness and threats mitigation approaches

WR.1. High investments in technologies

As previously reported, a cost-benefit analysis based on the processing and knowledge needs is recommended to avoid excessive unexpected high investment costs. Starting with a proper needs analysis is also useful to schedule more investment stages over time.

WR.2. Little effectiveness in restricted time situations

DSS may not be used to replace decision making but to provide useful information to support them; thus, it is best used for planning and optimization purposes rather than restricted time situations. If DSS is intended to give suggestions in a timely manner, it is recommended to carry out a special feasibility evaluation at the design stage.

WR.3. Difficulty in results interpretation

To avoid system poor effectiveness of DSS, it is recommended to plan and carry out a training program for decision-makers with some simulation of major processes and function even running prototypes with samples of real data. If possible, special training-on-the-job program it is also recommended to help users to become more familiar with technological tools.

As for possible overemphasize decision making, it is important to educate managers about the broader context of decision making and the social, political and emotional factors that impact processes.

WR.4. Lack of technology knowledge

Lack of technical knowledge is strongly related to difficulty in result interpretation (see WR.3); thus training programs and simulations should be designed jointly both for data interpretation and operational skills improvement purposes.

WR.5. Employees' resistance to change

To avoid the potential negative issues in employees' resistance to work with new IT tools it is recommended to design and carry out a special training program that highlights the benefits of the solution and explains techniques and advantages in using the tools. The training-on-the-job format may be an effective way to perform the program.

TR.1. Resistance in acceptance by decision-makers

The strategy to avoid system acceptance resistance should be defined and implemented in a comprehensive training program including previous WR.3 and WR.4.

TR.2. Algorithm development and maintenance

It is very difficult to assess the resources required by DSS maintenance/update in the early design stage. However, the allocation of resources/personnel to carry out this task have to be considered in order to prevent an increasing reduction of system effectiveness.

TR.3. Difficulty in operational processes integration

DSS may not be used to replace decision making but to provide useful information to support them; thus, it is best used for planning and optimization purposes rather than operational ones. Basically, DSS is mainly useful for verification and cause-result analysis of business and operation activities.

TR.4. Lack of qualified labour force

Also, in this case, to avoid issues, it is recommended to assess the needs of specialized professionals and develop a training program to provide adequate skills to existing or new staff.

5 Final considerations

5.1 Mutual synergies between innovations

The first aspect that emerges from the first series of SWOT analyses is that almost all innovations can be considered "in synergy" with all others for at least two reasons: 1) each of them can be implemented together more effectively thanks to the existence of many common parts; 2) one of them is a prerequisite that must be implemented before the other. In many cases, it is not easy to understand if the relationship between two innovation is of type 1 or 2, even if it's not really crucial.

Some examples of this are the relationship between Document Digitalization and PCS, but also DSS, WMS, and Mobile Solutions; indeed, Document Digitalization may be intended as a fundamental prerequisite of all other innovations as well as enabling factor for those of Data Management Tools and Traffic Automation Systems analysed in deliverables 4.2.1 and 4.3.1.

This highlights that, implementing one of these innovations, carrying out a cost-benefit assessment of some different integrated development scenarios in which more than one innovation is developed, might provide useful information for the decision-making strategy.

Moreover, from another point of view, this puts in evidence that many innovative pilot solutions of WP5 have to be implemented combining more than one specific innovation.

5.2 Recurring features and issues

Some recurring benefits and positive repercussions come from this first series of SWOT analysis. If we summarize/categorize strengths and opportunities of selected informatization processes, we can see that at least these five are hot topics on average relating to three or four innovations:

1. **Processes improvement**: processes speed-up, automation, implementation of new features, safety and productivity increase
2. **Planning capability improvement**: better programming, forecast, assessment, analysis

tool, and techniques improvement
3. **Communication**: improved information exchange, data sharing, and actors interaction
4. **Services overall effectiveness and quality**: errors reduction, more objectivity in decision-making, increased transparency and more information available for passengers and operators
5. **Environmental impact reduction**

As for critical factors and issues highlighted in weaknesses and threats, we can see that there are at least other five hot topics summarizing them:

1. **Infrastructure modification**: tools replacement and upgrade, system integration, increased costs in infrastructure and related work costs
2. **System complexity related risks**: process disruption, bad results, data unavailability, hardware failure, local inapplicability, design, and testing related costs
3. **Lack of skills**: the need for qualified/trained staff, internal organizational issues, internal and external acceptance issues
4. **Approach limitations**: technological intrinsic limitations, physical and local constraints, untested techniques
5. **Digital security**

Especially in relation to critical factors, some final general considerations can be made.

When facing infrastructure modification and system complexity, it is very important to adopt a multi-stage design approach that includes at least a stakeholders consultation stage, concept definition stage, prototyping and testing, final detailed design stage.

The best way to face a lack of skills issues, both at the operational and decision-making level, is to design and carry out special education and training programs, which would be better if held in blended formats such as a laboratory, training on the job, e-learning, self-training.

The physical, technological and methodological limitations must be addressed by creating prototypes and tests to simulate working conditions, while digital security aspects must be treated with the contribution of qualified experts in both technological and regulatory aspects.