DigLogs

4.1.2 - SWOT on selected data management tools for freight and passengers mobility

CFLI

Responsible partner: CFLI Involved partners: All			
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0.1	Draft	30/01/2020	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 analyses 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 solutions deployment.

During WP4, project partners will enlarge the partnership to collect inputs and contributions from stakeholders, revise and integrate roadmap in order 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 actors 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 on the basis of 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.
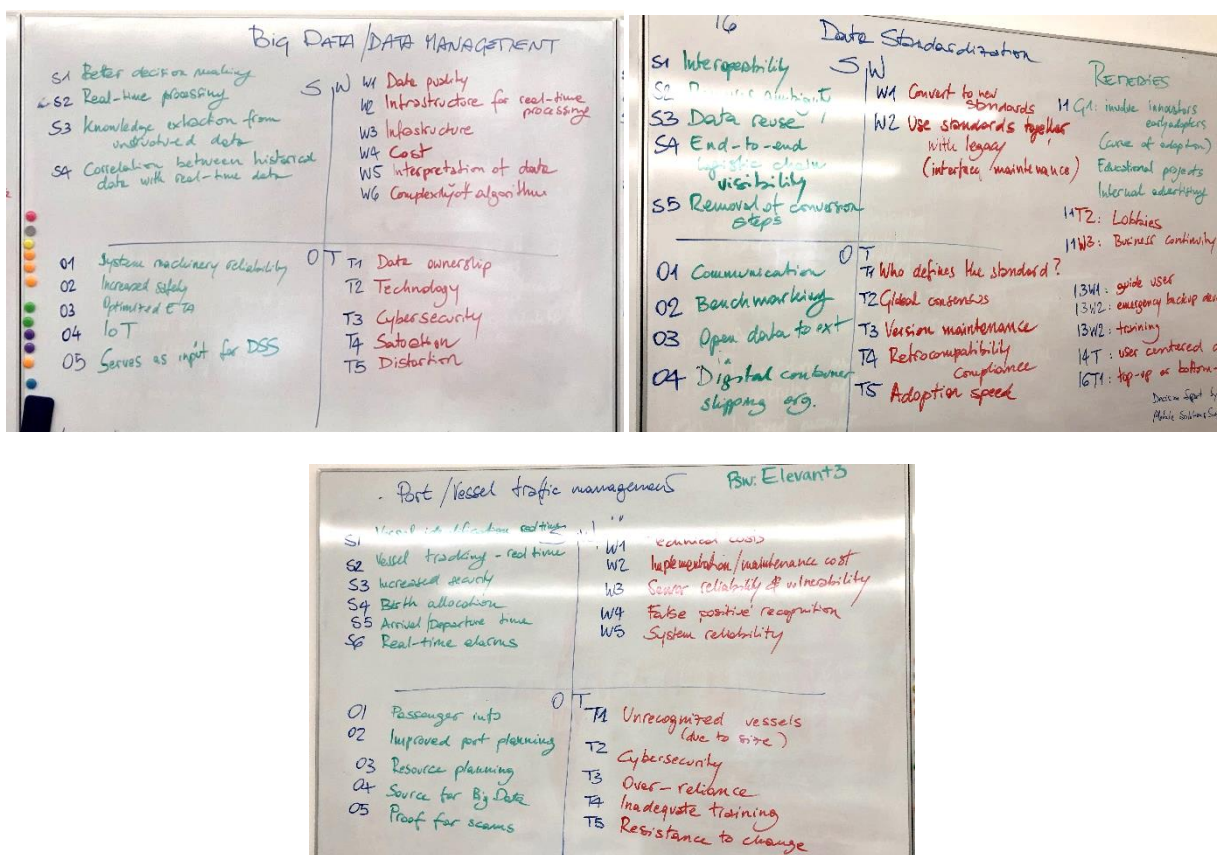
4.1.x deliverables also take into account the LP contribution provided on February 7th, 2020 by the report "DIGITALIZING LOGISTICS PROCESSES (DIGLOGS). SWOT analyses of selected 11 innovations" drafted by Aksentijevic Forensics and Consulting, Ltd. for University of Rijeka and revisions by PP4 University of Trieste provided on February 10th, 2020.

3 Objectives of this document

This deliverable is about SWOT analysis of the <u>second</u> category of innovations: <u>data management tools for freight and passenger mobility</u>.

Chapter **Errore. L'origine riferimento non è stata trovata.** contains the core analysis and 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 Maritime Big Data/data management

4.1.1 Innovation summary

Since a clear definition of the term "Maritime Big Data" does not exist, Maritime Big Data can be defined as a large amount of data generated inside and outside the maritime transport network and it can include anything about ships, freight, weather data, labour costs, oil and metal prices, operators' work, as well as those produced by bridge equipment such as Voyage Data Recorder (VDR) and Automatic Identification System (AIS).

Many of these datasets are georeferenced, and most of them can be georeferenced by correlating them to some others; anyway, to obtain the best results from these data, in terms of added value in knowledge and management capability, effective and usable management, processing and visualization tools, as well as special methodologies, are needed.

Introduction of Big Data Management and Analytics is expected to change both the decision-making and operational processes, enabling stakeholders to make optimizations and predictions and perform faster decisions.

4.1.2 Needs, challenges and opportunities

Big Data and data management innovation comes from the strong need to exploit a large amount of available digital information to improve planning and port operation. Indeed, the great majority of those data is mostly underutilized due to the lack of skills and tools. It seems to be quite evident that many advantages can come from the exploiting of real-time data processing and enabling spread connectivity between systems while there are risks and weaknesses related to the heterogeneity in data sources, processing complexity, unclear investment costs and some resistance to change.

4.1.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Increased efficiency, safety, resource utilization 2. Improved collaboration between stakeholders 3. Heterogeneous data processing 4. Smart IoT devices connectivity 5. Real-time data management and processing 6. Fast data processing and aggregation	1. High investments in technologies 2. Need for development of new-generation devices 3. Difficulty in interpreting proposed decisions 4. Difficulty in classifying unstructured information 5. Data ownership management 6. Need for specialized expertise
OPPORTUNITIES	THREATS
1. Smarter products and services fostering 2. Safety and environmental impact improvements 3. New information from unstructured data 4. Influence on the future DSS processes	1. Data access and sharing issues 2. Processes dependency from data sources 3. Processing times issues 4. Security issues 5. Regulatory issues

4.1.4 Strengths

S.1. Increased efficiency, safety, resource utilization

Big Data and Data Management Systems improve outputs, increase process efficiency while at the same time reduces costs. In the future, also more effective cooperation between actors is expected due to improved information sharing and real-time data availability. Better resource utilization might also be achieved, including for example the paper document reduction or elimination.

Big Data Analysis and Data Management ensure higher safety at sea, for instance by preventing collisions and machinery failures. It also improves overall outputs tending to reduce costs in the long term ensuring resource usage optimization and effectiveness in business processes.

Regarding the safety of ship operations, it can be affected by several different reasons (sinking, acts of piracy or collision), but many other data need to be monitored, such as current weather,

engine and technical components, ships details and positions. Real-time weather and ship data can help to detect dangerous situations or re-routing vessels outside of the critical areas.

S.2. Improved collaboration between stakeholders

Data-driven decision making and operation give more objectivity and transparency helping to increase cooperation between stakeholders. Moreover, the result in paper documents reduction or elimination can improve communication and information exchange between actors.

Internal platforms are getting developed to provide more efficient use of collected data, so future prospects anticipated through the more efficient use of collected data is a higher level of cooperation between the actors in a transport operation or supply-chain. For example, data provided by ships sailing within a hazardous area can help other ships to avoid the same difficulties, improving the safety of the crew and other ships.

S.3. Heterogeneous data processing

Big Data and Data Management methods and tools are specifically designed to manage different kinds of information. The possibility to collect and analyse data from various internal and external sources is a key factor and it may be useful to industries and organizations that own a huge amount of digital information they are not able to exploit.

Data Management tools can handle structured and unstructured data coming from different owners and systems, integrate them providing several analysis functions, fast and effective storage, conversion/transformation, transfer and visualization of massive amounts of data giving evidence of many known and unknown dynamics and events.

S.4. Smart IoT devices connectivity

IoT is a field in which pervasive connectivity and digital data are the key factors. Having a strong and coherent data system is the basic condition to enable devices to exchange data and provide operational control.

S.5. Real-time data management processing

An effective interoperable data system can handle and analyse real-time or near-real-time data enabling businesses to offer their services through IoT and related machines and devices.

One of the key issues is about predictions of arrival times and calculations of the needed speed. Generally, many inefficiencies are related to delays caused by uncertainties of weather conditions, arrival times of prior ships, loading/unloading processes, etc. that lead to waiting times on available slots for arriving ship being anchored outside of the port. AIS and weather real-time data can help to prevent this situation, calculating optimized routes matched with real-time data of outside circumstances.

S.6. Fast data processing and aggregation

Big Data/Big Data Management and Analytics enable faster decisions, more accurate predictions, faster reactions to changing conditions (traffic, weather, etc.), a better estimation of arrival, departure times, work estimates.

4.1.5 Weaknesses

W.1. High investment in technologies

Big Data and special dataset (e.g. geospatial data) management need significative resource investments in implementing proper hardware and software tools.

Often, there is a lack of suitable devices that makes it hard to store and process a large amount of incoming data and provide proper real-time information in order to support ongoing transportation operations. Moreover, the traditional database management tools are mostly insufficient to manage Big Data and/or geospatial data; indeed, Big Data and geospatial data management, in general, refers to the collection of large and complex datasets for which special tools are needed.

Also, when handling Big Data and geospatial data, advanced data-processing techniques are required in order to effectively analyse and use the information; special technologies or methods, such as algorithms and models to handle Big Data are needed.

Past shipping crises, the falling freight rates, oversupply and margin pressure have slowed down the further development of Big Data solutions. In such an unstable environment, investors are uncertain about implementing new technologies.

W.2. Need for development of new-generation devices

Big Data and geo-location analysis often require special devices and hardware to acquire and/or send data through the network. This means we need a new type of devices (IoT), with new enhanced communication capabilities and real-time data handling.

Moreover, the base infrastructure may need to be re-designed since the existing storage and processing systems could be not suitable to handle massive amounts of data, taking into account that real-time information management is particularly important for Big Data Analytics applications, especially for those about the alert and warning systems.

In addition, an environment that supports the development of new solutions, in maritime transport, still does not exist. It is necessary to provide a safe surrounding for tests, experiments and pilot projects regarding the successful Big Data management in maritime transport.

W.3. Difficulty in interpreting proposed decisions

The systems based on Big Data and multi-criteria analysis must be intended as a Decision Support System, not as Artificial Intelligence devices that make decisions in place of humans. In many cases, the lack of knowledge and understanding can make difficult to properly interpret the outputs of a complex data analysis system and validate or confirm the logic behind the results. Bad tuning of the Decision Support System may also lead to poor quality analysis and misleading information.

Lack of knowledge and special skills may have a huge impact on Big Data and data-driven systems regarding the capability of planning and design processes at the strategic, tactical and operational levels, especially for what is about tuning algorithms and data models.

W.4. Difficulty in classifying unstructured information

To make a correlation between different datasets it is very important to optimize information by making classifications and standardizations; in most cases, the lack of well-defined standards and

techniques make every stakeholder design its own procedures and structures that are hard to be related to the ones of other players.

Often, to extract some good quality data, it is necessary to process huge volumes of raw data generated from different independent sources along the path of the transportation and supply chain of goods; dealing with a large number of independent stakeholders means dealing with several independent systems.

W.5. Data ownership management

When working with interoperable data systems, the ownership is often unclear, and, at the same time, many data are of the utmost interest of the owner (e.g. confidential information). There may be several cases in which confidential information databases are not shared within the community though it might be very useful to other stakeholders who want to carry on special analysis by integrating that information with the owned ones.

W.6. Need for specialized expertise

Developing Big Data solution requires new skill sets, validation of collected data technological knowledge in analytics, statistics and software modelling. It requires experts such as computer scientists, mathematicians and data scientists for interpretation of results of Big Data Analytics.

Developing the new devices for data processing and validating the collected data is labour intensive and requires a high degree of special technological knowledge; the maritime transport suffers from a lack of skilled workforce, a problem that is expected to increase in the future.

4.1.6   Opportunities

O.1. Smarter products and services fostering

Big Data Management can lead to a new generation of innovations and better decisions in the supply chain community, basically exploiting the potential of machine learning techniques, real-time data processing, and predictive methods.

The advantages may be regard efficient routing (tracking and delay factors data matched processing), operation optimization (predictive maintenance, failure risk detection, needless

service identification) and safety improvements (collision risk and machinery damage risk detection,) up to future autonomous shipping and e-navigation. Many innovations may be enabled by exploiting mobile app technology and Machine Learning integration.

Moreover, human resources management can gain advantages from the implementation of Big Data too; indeed, the analysis of personal data can help to improve the general health of the workforce, by monitoring data about the weekly workload. Stress issues can be detected and occupational accidents, as well as long absences due to illness, can be prevented, which is another aspect of cost savings.

As for physical and virtual security, real-time prediction and Machine Learning can give great benefits in avoiding attacks and critical issues.

O.2. Safety and environmental impact improvements

Higher efficiency, sustainability and better environmental protection of port activities can be achieved by adopting an effective Big Data / Data Management system. For example, geospatial datasets processed by GIS systems integrating ship tracking systems can lead to a more comprehensive management strategy for the port operation that takes into account all the environmental aspects related to the wide community geographical area, also helping in dealing with the regulation framework compliance.

As already mentioned, more efficient routing, optimization, damage, and operational risk reduction can be achieved collecting data streams from sensor networks installed on ship engines and machinery, also integrating them with other external data sources (e.g. AIS, weather, etc.) as well as with Machine Learning in order to better estimate traffic conditions and reduce risk of collision. Moreover, Big Data and Data Management systems can also improve staff safety and health by monitoring workload and activities.

O.3. New information from unstructured data

Maybe the most significant feature of Big Data is that it is in most cases unstructured since it comes from the Internet. Unstructured data cannot be directly processed by information systems so, a transformation process is needed before using this data, which is often a hard task to carry out. On the other hand, unstructured data is very easy to collect, though we need a properly dimensioned system to store it, since its size may be considerable. Today many techniques are

available to extract useful information by correlating unstructured data so there are many opportunities to design new products and services based on the exchange of information previously unavailable in a digital format.

O.4. Influence on the future DSS processes

The overall interest in the use of Big Data is rapidly increasing; at the same time, a rising number of companies are offering high-technology solutions to optimize ship operations using brand new data sources arising every day, and this number is expected to increase continuously in the future.

Introduction of Big Data Management and Analytics may change the decision-making process; the so-called data-based or knowledge-based decision making is already present in numerous successful applications in the maritime and logistics sectors, which is definitely a very suitable environment for this kind of innovations. Today, the prediction accuracy in the area of logistic processes (for example, predictions of vessel arrival times and the needed speed adjustment) is basically insufficient and the new methodologies and technologies are expected to significantly improve it, leading to a long term scenario of cost reduction and improved operational performances.

4.1.7 Threats

T.1. Data access and sharing issues

For some kind of source (e.g. VDRm, AIS, IOT) there may be some resistance to share data by stakeholders.

In addition, some competitive conditions may arise by storing many datasets in the same infrastructure; in this case, it may be difficult to overview the different owners and to avoid the monopolization of property rights when a strong demand for only one data provider leads to monopolistic deals. Generally speaking, the absence of data ownership regulations and the inability to ensure access for all those involved in the process of collecting and deriving data may be a severe issue.

T.2. Processes dependency from data sources

When particular processes are steadily dependent on some Big Data Analysis outputs, especially for those obtained using external data sources, a special weakness may occur considering that if some data sources become no longer available/reliable, the goals of the processes cannot be reached.

Also, the risk of inability to adapt processes according to rapid changes in technologies and data sources may lead to a failure situation.

T.3. Processing times issues

In Big Data Analysis and real-time based prediction systems, processing time becomes critical. If some data sources give unexpected too high volume, processing tools, algorithms, and models can decrease in performance or even stop returning outputs. In such a situation, there is little time left to fix the issue.

T.4. Security issues

Security issues basically relate to cyber-threats but also to data retention and system reliability.

First, data needs to be protected from unauthorized access, especially because wireless data exchange is at risk of interception or penetration by cybercriminals and terrorists. The implementation of Big Data solutions may make the maritime transport more vulnerable. Definitions and guidelines regarding illegal activities, contrast strategies, personal data secure handling are mostly missing.

Regarding reliability, various stakeholders may be forced to rely on a system in which data is provided by some other involved parties; since many decisions can depend on the analyses' outcomes and related data, those resources must be reliable and secure.

T.5. Regulatory issues

Regulations regarding the digitalization might differ from each country or even within the same country. The implementation of a particular technology or business model across differently regulated areas or countries could be an issue.

4.1.8 Weakness and threats mitigation approaches

WR.1. High investment in technologies

A proper estimation of needed investment in technologies to implement Big Data Analysis solutions can be hard to do since precise information about the type and size of data sources to use may not be available.

In these cases, it is recommended to design an implementation plan, as detailed as possible, dividing activities into sequential self-supporting stages. In this way, technology costs estimation may be easier to do. Dividing a complex solution into several implementation stages allow investments to be addressed in a modular way, instead of making a whole big investment all at once. It also makes feasible to plan the use of different resources and funds (e.g. EU projects) over time, distributing them according to the implementation progress.

It is also recommended, when feasible, to design and run some prototypes to test hardware/software needs and performances.

WR.2. Need for development of new-generation devices

This topic is highly related to the one about investments in technologies (see W.1, WR.1). In addition, more resources have to be reserved for the acquisition and/or training of needed specialized skills; about this, it might be useful to design a special educational plan with which distinguish skills and resources to be internally improved and the ones to be acquired from the labour market.

Even the re-design existing infrastructure may result in the need for a special dedicated project that is recommended to avoid process interruption and unexpected costs.

WR.3. Difficulty in interpreting proposed decisions

Even for this weakness, knowledge, and skills owned by operators and decision-makers is a key factor. To gain high benefits from data analysis systems, users have to be properly trained both for input data definition and output result communication and interpretation. At the decision-making level, end users must have a basic knowledge about data and processing model to avoid misleading and bad interpretation.

As for W.1 and W.2, also for this weakness, it is recommended to design a special educational plan, starting from an existing skill analysis addressed to both operational and decision-making levels.

WR.4. Difficulty in classifying unstructured information

Designing data structures and models is a crucial aspect of any Information System. This is truer when speaking about Big Data and other by-definition unstructured data since the real added value in data processing comes from the correlation between several heterogeneous sources. Furthermore, the lack of standards makes everything more complicated.

To face these issues, it might be helpful to design an overall data model to help to identify classes, structures, and connections between data sources. It is also recommended to involve other stakeholders during analysis and project development in order to come to shared definitions about the standards to be adopted.

WR.5. Data ownership management

To improve data sharing between stakeholders, the definition of special agreements between parties might be helpful. The terms of each agreement can be defined by carrying out dedicated workshops during which risks and benefits are discussed and common points can be established.

WR.6. Need for specialized expertise

In general, computer science, mathematics, and data science skills are still unavailable inside organizations, so it is essential to develop a recruitment plan combined with a proper training program.

Enough quantity and quality of human resources might be ensured through cooperation between universities and the private sector for the further development and implementation of Big Data solutions in maritime transport.

TR.1. Data access and sharing issues

As it is known, many cases of resistance to sharing digital data are not related to the legal framework but to a lack of transparency and cooperation regarding the use of that data. This

issue can be overtaken by establishing trusted cooperation between parties in which each one knows the benefits brought by data integration. In this scenario, mutually acceptable agreements and legal framework with clear instructions and rights can be implemented by parties ensuring interoperable conditions.

From a technical standpoint, data sources can be shared either by implementing a centralized database or by developing special web-services that can provide properly anonymized, simplified, aggregated or transformed information to third parties.

TR.2. Processes dependency from data sources

To avoid low performances caused by temporary data source unavailability, it is recommended to define special procedures to be executed to ensure the minimum objectives. It is important to ensure an effective monitoring system capable to send warnings at the right time in case of data providing failures.

TR.3. Processing times issues

This threat can be mitigated by doing dedicated simulations of critical system functions and/or testing them using dedicated system prototypes.

TR.4. Security issues

Security issues are highly recurrent in the digital-data-enabled application. The 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, IT security, data retention, and other technology-related security aspects.

Security and transparency must be built in the technology and processes at all levels. It is important, that used solution allows easy revision trail, logging of activities.

Regarding data retention, since volume and variety of data are expected to be very high, an active special policy should be part of the retention strategy.

TR.5. Regulatory issues

Any regulatory issues must be addressed in the design stage of a technology or business model implementation. A qualified professional can be helpful in finding alternative scenarios when the solution cannot be applied due to regulatory constraints.

4.2   Data standardization

4.2.1   Innovation summary

In the digital scenario, many organizations and companies are leveraging data to intelligently plan their operations aiming to improve efficiency and security. To create added value from data processing and analysis, standardization and protocols are key factors because they allow reducing errors and inconsistency, correlate different data sources, easily exchange information between stakeholders, increase interoperability and data reuse.

Basically, data standardization can be intended as a series of optimizations that gives to the same information the same shape, since computer application are unable to relate two information if they aren't identical. Many of these shaping rules, grouped together according to an objective, a process or a function, can result in a specific protocol that must be adopted by each involved actor or technological system.

To reach a new level of data standardization, a broad consensus from all involved actors, or even an ad hoc consortium, is needed in order to define and test beginning versions, testing and tuning systems and disseminate the final version for the wide adoption.

4.2.2   Needs, challenges and opportunities

Data standardization is required when many data sources are available and the need arises to speed up communication, connect systems, automate functions eliminating some unnecessary steps in the digital information flow. Main challenges are more related to the difficulty in involving stakeholders and the complexity in development and maintenance over time.

4.2.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. The right information at the right time 2. Easy connection between data sources 3. Logistic chain knowledge improvement 4. Data re-use	1. Intrinsically complex implementation 2. Hard to obtain standardization acceptance 3. Difficulties in backward compliance to standards 4. Resistance to revise processes 5. Risk of process disruption
OPPORTUNITIES	**THREATS**
1. Reduction of cost and errors 2. Easy custom interfaces development 3. Effective implementation strategies 4. Processes optimization 5. New opportunities for single-window solutions 6. Data visibility, transparency, and certification	1. Standardization acceptance issues 2. Low speed in standards adoption 3. Maintenance complexity 4. Security issues

4.2.4 Strengths

S.1. The right information at the right time

Standardization means better availability of the right information at the right time, that results also in improved communication and information exchange between stakeholders. Standardized datasets facilitate information exchange both externally and within the organization, as well as automated data exchange between technological platforms thanks to interoperability protocols. It improves also integration, coordination, and performance of the supply chain, business, and administrative operations reducing errors and costs.

S.2. Easy connection between data sources

Every time a need arises to relate different data sources, a special optimization is required to make information joinable. Standardization highly reduces the need to carry on ad hoc optimization when connecting Information Systems, also reducing related costs.

Often, standardization takes into account the most effective way to connect data sources and results in faster overall processing times.

S.3. Logistic chain knowledge improvement

Data standardization foster a better end-to-end logistics chain data visibility; it also brings data into a common format that enables collaborative research, large-scale analytics, and sharing of sophisticated tools and methodologies between stakeholders.

Result data exchange improvement allows multi-country and multi-industry knowledge exchange and foster optimization of both communication and efficiencies within a large and complex network (for example, maritime industry).

S.4. Data re-use

Stakeholders can reuse information provided by the system instead of entering it all the time and easily process data since it is converted into common formats, enabling collaborative research, large-scale analytics, and sharing of sophisticated tools and methodologies. Moreover, standardization enables easy data exchange between different countries and companies.

4.2.5 Weaknesses

W.1. Intrinsically complex implementation

Data standardization in logistic chain systems in intrinsically complex, involving both data science skills and knowledge about logistics market and operations.

One of the key points is that collected and stored data should be integrated together in order to obtain a complete scenario, indeed a mix with new standardized data sources and historical data is highly needed to draft typical analytics and reports; to do it, data should be normalized and standardized before combining different versions of similar datasets.

W.2. Hard to obtain standardization acceptance

Standardization involves by-definition more actors; in most cases, it is particularly difficult to obtain the consensus of standard and later usage of standard between different stakeholders.

On the other hand, companies and organizations are usually cautious about adopting new technologies since there are no common data standards in the market.

W.3. Difficulties in backward compliance to standards

One of the typical issues regarding standardization is that a new version of standards may not be backward compliant so it may become hard reusing new standardized data in combination with historic data with consequent limitations in reporting and analysis.

W.4. Resistance to revise processes

Adopting standards and protocols may require process revision or re-design which always causes resistance by employees. Resistance can also arise because supply chain company and organizations are already using their own management solutions and may not want to replace them with more standard-compliant ones.

W.5. Risk of process disruption

Data standardization does not bring complete process automation; employees should always monitor the data quality. Full reliance on automation can lead to a situation where poor-quality data can disrupt a newly streamlined process (if "human control" is not present anymore).

4.2.6 Opportunities

O.1. Reduction of cost and errors

With more standardization and system effectiveness, employees can more focus on service quality instead of wasting time fixing errors or data inconsistency. Further, data consistency and quality will foster better planning and, consequently, better resource utilization in the maritime and supply chain industry.

O.2. Easy custom interfaces development

Standardized and consistent data, as well as effective exchange protocols and platforms, are key factors for easy and less expensive custom applications and interfaces development and maintenance. In addition, a better-developed application can make employees save time in data entry and focus instead on service quality.

O.3. Effective implementation strategies

Standardized data and protocols allow the gradual implementation of new applications and functions within the existing solutions and launch new interfaces and keep the old ones working in parallel.

O.4. Processes optimization

Data standardization will basically result in faster data availability so it will change not only the applications but the process of supply chain management itself. For instance, Maersk, MSC, CMA CGM, Evergreen Line, Hyundai Merchant Marine, Yang Ming Marine Transport Corporation and ZIM Integrated Shipping Services) have established the Digital Container Shipping Association (DCSA) to create common information technology standards, a common foundation for technical interfaces and data for the maritime industry. DCSA is helping the industry define the baselined process standards from Booking to Return, including sub-processes, milestones, events, and messages.

O.5. New opportunities for single-window solutions

Since the less standardized the data, the more complicated and expensive it is to develop single window solutions, new opportunities in launching new interoperable platforms may arise when companies and organizations implement a data standardization program.

O.6. Data visibility, transparency, and certification

Standardized data is easier to certify, for example using blockchain-based solutions, and to be shared among parties resulting in greater visibility and transparency of operations.

Data standardization can also improve cybersecurity; database integration may enable security systems to more efficiently detect patterns of suspicious activity and allow algorithms to more rapidly learn from past patterns to detect future attacks.

4.2.7   Threats

T.1.   Standardization acceptance issues

As already mentioned, for many reasons, obtain large consensus and wide adoption of data standards and protocols by many players might be very hard. On the other hand, if numerous players do not support data standardization, desired goals (increased speed, accuracy, planning, etc.) will not be entirely achievable.

Probably, one of the major risks is employee resistance, since in many cases they may not want to change their way of working because benefits are not so evident from the beginning.

There is also a risk, that organizations will not recognize data standardization as a basis for innovation and process improvements due to the lack of knowledge of digital technologies, thus continuing with the same process and work organization as before the change. This might occur also when companies don't own proper technologies and procedures that allow them to use the standardized data.

T.2.   Low speed in standards adoption

The speed of adoption of standards may be too slow than expected, leading to partial failure of innovative solutions implementation. This might occur when data standardization requires changes in data management and operation processes and when some steps become obsolete while others must be introduced. Failing to adapt processes to the new standard structures would mean not taking real advantage of innovation projects.

A further possible cause of low speed in standard adoption might refer to particular local work environments that are not ready to accept data in the new standardized ways, generating more confusion and mistakes than expected benefits.

T.3.   Maintenance complexity

Maintaining the operation of systems based on multiple versions or sub-versions of standards can be a real challenge, since some standards may not be backward-compliant. This is even more serious considering that standards definition is very strict referring to a multi-actor and long-term design scenario.

T.4. Security issues

Security weakness can be the flip side of data standardization when done using inefficient methods, especially considering that regulations have made data retention mandatory for several years. Cyber-threats may be simpler by exploiting vulnerabilities in standards and protocols.

4.2.8 Weakness and threats mitigation approaches

WR.1. Intrinsically complex implementation

Before implementing standardization operations, it is recommended to define a group of players that agree working together to develop new standards and carry on a detailed assessment of available data sources owned by each one. A general census of datasets can be highly useful in mapping relationships between them and for identifying priorities in standard definitions.

It is also recommended to assess within the staff the availability of special skills that can be addressed in standardization design, test and implementation, in order to make dedicated workgroups and speed-up the general process.

WR.2. Hard to obtain standardization acceptance

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.

WR.3. Difficulties in standards backward compliance

Backward compliance issues in standardization are hard to mitigate weakness due to the impossibility to predict the evolution of technologies and related conventions. To mitigate this risk, it is recommended to constantly assess the evolution trend of standard definition, assigning to this task adequate economic and human resources.

WR.4. Resistance to revise processes

As already mentioned for other cases, to mitigate the risk of resistance by employee it is recommended to well communicate goals, give visibility of benefits, listen and include user

opinions and contributions from the staff using surveys or other techniques and, if needed, carrying out training or workshop to improve skills and knowledge of operators.

WR.5. Risk of process disruption

To mitigate the risk of process disruption, a special assessment to have a prior vision of possible scenarios can be helpful to reduce the impact of minor or major issues in work processes. From this evaluation, it is possible to extract specific intervention guidelines to help deal with critical events.

TR.1. Standardization acceptance issues

Acceptance issues may be both weaknesses and threats (see also WR.2 about remedies). Basically, to reach the desired effects of data standardization in the work process, employees will have to be trained to work with new solutions, so it is recommended not to underestimate the importance of training.

The impact on a particular work process should be assessed before applying a particular solution (on production level), allowing the transfer of the responsibility, satisfaction of engaged employees and control of the processes.

At the decision-making level, some companies or organizations may not recognize data standardization as a base for process innovation and improvements, thus continuing with the same process and work for organizations as before the change; in this case, adequate education may be needed also for decision-making level.

TR.2. Low speed in standards adoption

To avoid low-speed situations in standard adoption, a detailed plan of data management and operation process modification is highly recommended before going to implementation. For what concerns enabling different work environments to properly introduce standards and protocols in their own processes, it is recommended to assess the state of the art of particular cases in order to program special activities, both training and system optimization, aimed at aligning all involved parties to an optimal starting condition.

TR.3. Maintenance complexity

Maintenance of standards basically relates to versioning and backward compliance. This can be a weakness (see WR.3) but also a threat since many players are involved both in the definition and implementation of standards. Regarding this, to better manage standard effectiveness over time it is recommended to create a consortium or association among involved actors, also entering into special agreements, in order to face in time each arising issue.

TR.4. Security issues

To avoid the occurrence of vulnerabilities, each standard and protocol definition must be defined with a special, detailed and widely accepted section dedicated to security threats. About this task, the involvement of professionals especially skilled in cyber-security is highly recommended.

4.3   Port / Vessel traffic management

4.3.1   Innovation summary

Port/Vessel Traffic Management Systems (VTMIS) are specialized Information Systems aimed at performing real-time vessel tracking and status in order to better manage traffic inside port, river and coastal areas. VTMIS has both management and safety/security purposes and they are based on a sensor network and transponders to fast and secure localize and identify ships within the monitored area.

VTMIS data streams generate a large amount of raw geo-data that id almost never stored for statistical analysis purposes, but which has a high potential in extracting added-value information in post-processing stages.

In many cases, VTMIS implementation is to be done integrating existing tracking and/or identification systems, so a special plan of system integration is needed.

4.3.2 Needs, challenges and opportunities

Port/Vessel Traffic Management Systems are basically needed to gain better real-time control of ship operations; the potential of statistical and geo-statistical analysis of historical raw data is quite unexploited.

Major challenges concern the investment costs and the technological complexity of infrastructures that can result in low-quality data, malfunction risks, and functional disruption.

4.3.3 SWOT matrix

STRENGTHS	WEAKNESSES
1. Increased port performance 2. Real-time monitoring 3. Better time estimation 4. Better resources usage forecast	1. Hard to obtain data sharing 2. Investment in new technologies 3. Investments in technologies maintenance
OPPORTUNITIES	THREATS
1. Better organisation of maritime traffic 2. Increased safety 3. Labour cost reduction for monitoring 4. New IT services development	1. Risk of poor data quality or unavailability 2. Risk of data misuse or misinterpretation 3. Security issues

4.3.4 Strengths

S.1. Increased port performance

Port/Vessel Traffic Management Systems will basically increase the overall port performance; real-time information about ship's position may reduce the occurrence of errors in time estimation helping to plan fast and effective loading/unloading activities, manage critical traffic situations in crowded environments. Indeed, improved traffic management means less time spent in waiting positions, corrections and optimal vessel passage queuing, assuring smooth operations.

In the deferred time, VTMIS can facilitate administration, monitoring, programming and reporting activities regarding cargoes and ships.

S.2. Real-time monitoring

Real-time information on the vessel status is the key feature of VTMIS, especially regarding tracking and monitoring purposes.

As for security and safety aspects, accurate detection, tracking, and identification of small and high-speed targets are highly suitable for generating automatic alarms, particularly when geospatial information can be correlated allowing the detection of ships entering special/limited target areas.

It is important to underline that real-time data about ship positions is probably one of the most important requested datasets among port community players responsible for port security.

S.3. Better time estimation

Processing real-time data about vessel position and tracking is the most effective way to better estimates the arrival and departure of ships, which are key factors in minimizing delays in port operation and improve efficiency.

S.4. Better resources usage forecast

Like the ship's arrival and departures, also for resource management, it is necessary to estimate times in order to forecast their engagement and usage. Better forecasting can help eliminate unnecessary waste of materials and resources, plan and manage goods properly, monitor inventory entering and leaving the port or even allocate specific areas within the shipyard.

4.3.5 Weaknesses

W.1. Hard to obtain data sharing

Like for other innovative solutions, even for traffic management solution implementation, a broad consensus of stakeholders to share their data with others may be hard to obtain.

W.2. Investments in new technologies

The solution requires the implementation of a series of sensors, positioned both in strategic port positions and potentially on the vessels themselves. Additionally, other sources of data available for vessel identification, such as Voyage Data Recorder (VDR) and external monitoring such as Automatic Identification System (AIS) can be used as additional information sources for the interpretation of traffic information. This will result in significant investment costs that may be unsustainable for some ports.

W.3. Investments in technologies maintenance

Like W.2 which relates to implementation, also maintenance investment costs may be a critical aspect and an item hard to estimate.

One example can be when some extra modules must be added because the designed monitoring system does not work as expected, for example, extra sensors to better cover monitored areas or new different types of sensors such as thermal cameras to gain better quality.

W.4. Vulnerability issues

Sensors and data sources must be connected in a secure way to the central control room for port traffic monitoring to avoid unauthorised connections.

4.3.6 Opportunities

O.1. Better organisation of maritime traffic

Introduction of innovative Vessel Traffic Management Information System can improve the organization of maritime transport, allowing better planning of docking and undocking operations, planning of logistic process and better use of port resources. This opportunity is related to S.1 but is more referred to as improvements that involve more wider the port community and possible synergies with technological development.

O.2. Increased safety

VTS will improve the safety of vessels, cargo, passengers and onshore resources.

The purpose of the VTS service is enabling the safe passage of ships and the efficiency of maritime transport in the area of responsibility, ensuring the protection of human lives and the marine environment. Identifying dangers in a timely manner is what vessel traffic systems are developed for. Information systems now play a major part in allowing information to arrive on time, making it possible to see if there is an issue and then send the necessary information back to the recipient. In this way, all the information can be evaluated in real-time and put in place preventative actions that will rapidly diminish the risk of events from happening.

VTMIS maritime transport surveillance and management services can be extended to management and information activities, related to the control and management of maritime transport, in order to improve navigation safety and to provide the safety of passengers and the marine environment.

O.3.   Labour costs reduction for monitoring

In the long-term, automated monitoring systems will lead to monitoring operators' reduction and consequently lower costs for monitoring and tracking of maritime operations.

O.4.   New IT services development

VTS can lead to the design of new IT services and applications based on real-time data; for example, it can include a mobile solution for providing information to passengers about port services. It can be directly connected to a multi-actor system organizing data flows and providing real-time information to different users.

4.3.7   Threats

T.1.   Risk of poor data quality or unavailability

Availability and reliability of data cannot be always guaranteed. For example, data entered the system can be inaccurate due to sensor failure or recalibration, false or stole identification information or latency in transmission.

In some cases, even stakeholders who do not want to cooperate may cause data unavailability.

T.2. Risk of data misuse or misinterpretation

Lack of adequate training and knowledge can lead to misuse and misinterpretation of data.

It is important to remember that VTMIS can be a valuable tool for better security and process optimization in ports, but it cannot become the sole source of control. As such, the solution is to be intended as a tool for notifying the security and traffic management officers that must be the factual decision-makers.

If the need arises for performing special/custom analyses of VTS data, a shortage of skill might occur since this requires a high degree of technical knowledge in analytics, statistics and software modelling, as well as experts such as computer scientists, mathematicians, and data scientists.

T.3. Security issues

Sensors and data sources must be connected in a secure way to the central control room for port traffic monitoring.

4.3.8 Weakness and threats mitigation approaches

WR.1. Hard to obtain data sharing

See also TR.1 in par. 4.1.8 for organizational and technical recommendations. In this case, the resistance may come because ships tracking data may be intended as "corporate data", so it is important to clarify shared goals and benefits for all parties in creating a common information system aimed at better manage port traffic.

WR.2. Investments in new technologies

See also WR.1 in par. 4.1.8. In this case, detailed estimation of hardware cost may not be difficult, and it may be highly helpful to analyse the cost/benefits ratio. In this case, too it may be worthwhile considering exploiting different financing and funds (e.g. EU projects) intended to be used for security and safety purposes.

WR.3. Investments in technologies maintenance

Maintenance costs are often underestimated. It is highly recommended to draw up a detailed maintenance plan from the beginning of the design of the whole system and to consider

adequate resources for this task within the general budget, also considering a margin for unforeseen.

TR.1. Risk of poor data quality or unavailability

The solution to hardware failure or recalibration might be a procedure which will facilitate the data verification, positioning and calibration of sensors, in order to assure the accuracy of data entered the VTMIS.

As already mentioned, resistance to cooperation might be faced with a proper communication strategy and involving parties from the beginning of system design enhancing roles and highlighting goals and benefits of the system.

From a technical standpoint, the risk of general failure caused by hardware malfunctioning can be mitigated also implementing an adequate backup solution.

TR.2. Risk of data misuse or misinterpretation

Security and traffic management officers should receive adequate training to understand all the functionalities, causes and effects of using VTMIS system, to use it at full potential. Failing to do, the risk is that the VTMIS solution data and notification will not be used or interpreted in the correct ways.

TR.3. Security issues

Sensors and data sources must be connected in a secure way to the central control room for port traffic monitoring. Consider involving especially skilled professionals in the design stage of system security.

5 Final considerations

5.1 Mutual synergies between innovations

The first aspect that emerges from the first series of SWOT analysis is that almost all innovation can be considered "in synergy" with all others for at least two reasons: 1) each of them can more effectively be implemented together 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.

An example of this refers to deliverable 4.1.1 and it concerns the relationship between Document Digitalization and PCS, but also DSS, WMS, and Mobile Solutions. As for Data Management tools, another clear example is the strong relationship between data standardization and Big Data management, or the one between Port/Vessel Traffic Management and ETA/ETD innovation reported in deliverable 4.1.3.

Also, in this case, this highlights that implementing one of these innovations, a lot of useful information for the decision-making strategy can be obtained carrying out a cost-benefit assessment of some different integrated development scenarios in which more than one innovation is developed.

As already mentioned, this put 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. As already done in deliverable 4.1.1, we can summarize/categorize strengths and opportunities of selected informatization processes; also, in this case, the five hot topics (on average relating to three or four innovations) can be confirmed as:

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 confirm the 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**

As already mentioned in deliverable 4.1.1, some final general considerations can be made, especially for what concerns critical factors.

For what is about 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.

Finally, for what specifically concerns Big Data / Data Management systems, Data Standardization and Port/Vessel traffic management, higher importance must be given to aspects related to real-time data processing exchange and sharing, high-level analytics, Machine Learning, and smart management techniques but also to the field of Service Design. Indeed, the Service Design concept refers to the activity of integration and organization of different types of resources, including communication artefacts and materials pertaining to a specific service, aimed at improving the relationship between supplier and end-user.

As for issues and criticalities, aspects related to technical implementation, system complexity and need for adequate skills are of particular importance.