How to Create a Cross-border Port Community by Networking Ports with Each Other: The Experimentation of the EasyLog System

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Abstract. This paper describes the real-world experimentation of an innovative ICT (Information and Communication Technology) integrated system, the so-called EasyLog system, which enables the exchange of operational information in an orderly and secure way between five Tyrrhenian ports. The proposed system, dedicated to ro-ro transport, is highly innovative as it allows a set of ports to exchange operational information in a simple and secure way, also adapting the necessary technological equipment of the gate to the different local needs. The experimentation demonstrated the efficiency of the system in the exchange of embarkation/disembarkation lists between the ports concerned, demonstrating its suitability to share essential information for the purpose of optimizing port operations. The developed system can overcome the barriers that typically hinder the development of ICT solutions shared between ports through a structure that guarantees the autonomy of the individual local systems while ensuring their interconnection through the so-called EasyLog Connector. The lean automation of port gates using smart glasses for augmented reality represents another element of innovation, allowing easy and flexible automation even in poorly digitized ports, or where economic or operational constraints make traditional gate automation complex.

Keywords: Smart ports · ICT · Port innovation · Virtual gate automation · Smart glasses for augmented reality · Ro-ro tracking

1 Introduction

Digital-based technologies, in particular Information Technologies (IT) and Information Systems (IS), facilitating communication and decision-making processes, are widely recognized as a key factor for the efficiency of logistics systems and intermodal chains [1, 2]. Around two-thirds of logistic managers declare themselves aware of the need to revamp their business model to survive in the digital age [3].

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Particularly, in the port community, IT and IS are believed to facilitate monitoring and decision making and to enhance the acquisition and distribution of information, as well as efficiency and security in operations [4–7].

The port community can be defined as an intelligent community, where the port node is a point of convergence of a multiplicity of actors, actions, and information. Cooperation and information sharing through digitization, as well as high-quality information, are recognized to be crucial for the efficiency and safety of port operations [8, 9]. It is also worth noting that digitization is becoming more and more popular also to compensate for the lack of physical port infrastructures through the development of intangible infrastructures [10], thus overcoming the natural physical boundary of port systems by emphasizing booking, prevention, and forecasting activities.

An increasing number of ports have now independently initiated technological and digital upgrading [11], but mainly in the container sector. As for ports and terminals dedicated to rolling traffic, also called ro-ro ports, the levels of digitization are generally low, although several best practices are available. Extensive use of traditional methods of document exchange and manual management of the entire gate-in/gate-out procedure is still predominant in many ro-ro ports, as well as random or non-optimized management of parking areas. Likewise, automated control systems for the duration of the port stay are rare and so are computerized archives of port accesses, with important limits related to security issues. Although several independent port-related digitization processes can be found, they are mostly adopted within larger ports and transport companies. More importantly, digital integration between the various ports and operators is still lacking, albeit necessary to embrace a more holistic vision of the transport chain [12].

Traditionally, ports exchange a couple of institutional data with each other but tend not to exchange operational data, which instead would be essential for better management of port activities. For example, in the field of ro-ro transport, the possibility to know in advance from the port of origin the list of oncoming ro-ro units would allow better planning and management of port activities, areas and equipment, with consequent greater efficiency of logistics operations. Similarly, the advance knowledge of ro-ro vehicles arriving for boarding from the road would allow optimizing not only the control and acceptance operations at port gates but also a better planning of yard areas.

This paper describes the real-world experimentation of a newly developed integrated IT system, the so-called EasyLog system, for the optimized and secure management of gate operations and the secure exchange of information in and between five Tyrrhenian ports with different levels of digitization. This work represents the continuation of a previous paper [13] that described the operational context of the implementation of the EasyLog system and the functional requirements underlying its development.

The proposed integrated IT system, dedicated to ro-ro transport, represents an element of absolute innovation of its kind as, for the first time, it allows a set of ports to exchange operational information in a simple and secure way, also adapting the necessary technological gate equipment to the different local needs. Using a logistic metaphor, the port nodes of the EasyLog system can be assimilated to control points of a transport chain where the ro-ro cargo unit is read and the information transferred to the next node, so that it can prepare itself to welcome the oncoming cargo in the best possible way. The EasyLog system can allow coordinating the maritime connections between its ports

with the implicitly expected result of improving cross-border mobility and encouraging the development of intermodality in the area.

The framework of the paper is as follows. Section 2 briefly describes the path of modernization of ports over the decades and the positioning of the EasyLog system. Section 3 describes the developed ICT integrated system, and its structure and functionalities. Section 4 introduces the test area. Section 5 describes the experimentation while Sect. 6 discusses its results. Finally, Sect. 7 concludes.

2 The Path of Digital Innovation of Ports over the Decades

Starting from the 1960s and until the 1980s, ports were mainly defined as industrial, as they were mostly a direct extension of the mining or manufacturing industry. In order for ports to become an integral part of the supply chain and a fundamental cog in not only industrial but also distribution activities, it is necessary to wait until the 1990s, when the growth of international markets and containerization, the relocation of production, and the development of emerging markets produced the lengthening of logistics chains and imposed the need for common standards and cooperation between the different actors involved.

Since the 1980s, the modernization of seaports has been shaped by digital innovation through three main stages of transformation [10]:

- first stage (1980s): transformation into paperless procedures (development of the first EDI-based port community system, development of maritime industry-specific UN/EDIFACT message standards, etc.)
- second stage (1990s–2000s): transformation into automated procedures (application of automatic identification systems AIS, introduction of radio-frequency identification for terminal operations, etc.). Mainly static information, lack of data exchanged in real time
- third stage (2010s–onwards): transformation into digital procedures to improve responsiveness and decision making and to support the ongoing interaction and connection between the actors involved (Internet of Things, big data, blockchain, artificial intelligence, digital twin, sensors, mobile technologies, cloud computing, machine learning, etc.). An ever-increasing number of ports are implementing Port Community Systems (PCS) to enable the targeted and secure exchange of information and increase cooperation within the port community.

Now, as supply chains become increasingly integrated and connected, the connectivity of stakeholders should be ensured not only within the single port community but also between the various nodes of the transport network [11]. The main obstacle to achieving this goal is no longer technological but rather linked to the resistance that some operators pose in changing the paradigm to their working approach: from a single activity approach to a process approach, from an individual approach to a system approach.

Several challenges have so far characterized and slowed down the development of shared digital solutions in the port community. Different levels of digital maturity between actors, missing standards, lack of systemic vision, the reluctance of operators to share information are some of the main obstacles which hinder the adoption of shared technological solutions in the port area [14, 15].

The innovative IT system presented in this paper tries to overcome the barriers above through the development of an integrated modular system that ensures the independence and autonomy of local systems while ensuring their simple interconnection through a shared information exchange protocol.

3 The EasyLog System

The conceptual structure underlying the EasyLog system originated from the need to share between ports of departure and destination some sets of information relating to goods moving on rolling stock. The driving idea was to design an IT system that could become a sort of standard model of communication between ports, aimed primarily at the rolling stock sector but open to use in other scenarios.

The basic functionalities of the system were developed to ensure the following requirements:

- interoperability with any ICT system already in use in the port
- data exchange capacity between ports equipped with different ICT systems (PCS, TOS – Terminal Operating Systems, ICT systems of shipping companies, etc.)
- future opening to additional ports
- use of open and extensible standards
- infrastructure not based on centralized supports, such as central servers or databases, to be maintained by third parties.

In line with these requirements, the EasyLog system is designed according to a modular and scalable structure in which each port independently manages its own local module. The main innovation lies in the concept of the EasyLog Connector. The latter is defined centrally to constitute the heart of the exchange system and is intended as a set of rules for data exchange, formatting, and availability of the data. The data are collected and processed in the local systems and subsequently transferred to the Connector for their analysis and distribution to the various actors (Fig. 1).

The Connector overcomes the need for a central server for data storage and allows ports to communicate with each other using a common language between the ports of origin and destination. The Connector is based on:

- resilience to input (different possibilities of data input depending on the available hardware environment)
- asynchronous connection for data exchange in “pull” mode (the data made available by the person who generates them are taken from the person who receives them)
- data exchange in the form of XML files with defined formatting schemes (XSD), universally readable

- remote access data repository via FTP protocol by the EasyLog user concerned.

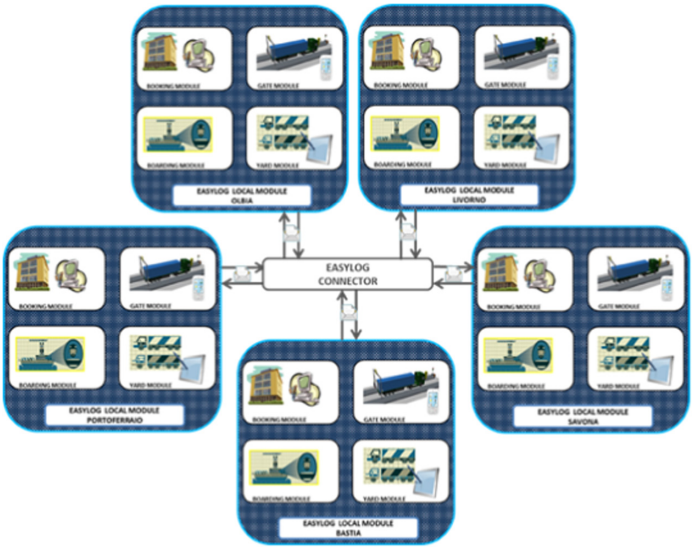


Fig. 1. Modular scheme of the EasyLog system. Source: EasyLog project

Each node independently provides both the software part relating to the interface of its local system with the EasyLog Connector, and the master data configuration of the other EasyLog nodes with which it is connected. This avoids centralized management of personal data and allows to independently manage the possible addition of new ports.

3.1 The Hardware and Software Components of the EasyLog Local Modules

The EasyLog local module combines hardware and software components installed at the various nodes that make up the EasyLog network. Such components include:

- hardware for reading vehicle license plates and other information of interest installed at the port gate
- dialogue software between the hardware and the information system
- Optical Character Recognition (OCR) software for automated license plate recognition
- software for processing and managing the data entered into the system
- hardware environment (computer, server) for the processing and management software
- hardware and software internet connection service for data exchange with other EasyLog nodes.

Depending on the local situation (purchase cost, budget availability, availability of physical spaces, integration with current procedures, local needs, importance attributed to

any other data of interest on the security side - attendance detection, access authorizations, time slot booking checks or operational process), the EasyLog system allows to implement the automation of port gates with different levels of automation:

1. Fixed hardware solutions through traditional portals equipped with cameras, illuminators, bars, etc. These solutions are preferable where the high volumes handled justify the high cost of set-up and maintenance. The access gates can be equipped with cameras for license plate recognition, columns with intercom, cameras for driver identity verification, barcode, QRcode and RFID readers, etc.
2. Virtual gates implemented by mobile hardware solutions without fixed infrastructure. These solutions are preferable where fixed solutions are difficult to set up, both for cost and operational reasons. The main hardware component of the virtual gate are smart glasses for augmented reality, for the purpose of recognizing rolling stock in port areas (Fig. 2). Smart glasses are equipped with an application system capable of acquiring, processing, historicizing, transmitting, receiving information from/to external systems. They capture and record images and videos on which to apply OCR algorithms for reading license plates and ADR codes (ADR - European Agreement concerning the International Carriage of Dangerous Goods by Road).
   The smart glasses are hands-free devices that mount on the operator's head and are robustly made for industrial use. One of the peculiarities of the device is that it is controlled through voice commands, thus allowing the operator to move freely and use the necessary tools and equipment, even while on the move. In this way the operator can maintain full awareness of the situation and maximum productivity. The smart glasses are equipped with an articulated arm that allows the operator to adapt them to his/her preferential eye. The viewer displays some applications that the operator can use for the recognition of vehicle and ADR license plates. They are also equipped with a satellite localization system, and wireless/mobile connectivity to allow communication to the back-end service.



Fig. 2. Smart glasses device used in the virtual gate. Source: EasyLog project

The software component of the virtual gate includes two application modules: a software component on the smart glasses, and a back-office software component for user management, manual data input, data query/control, and data transmission/reception via the EasyLog Connector. The data collected and processed by the software component

of the smart glasses are exchanged with the back-office component where they are processed and then transmitted to the EasyLog Connector.

The back-office software component is a web application and consists of the following macro functions:

- management of the truck announcement process
- creation of the loading lists based on the forecast of arrival
- import of cargo lists of incoming ships through the EasyLog Connector
- sending the loading lists of departing ships via the EasyLog Connector
- management of gate-in/gate-out activities of rolling stock
- management of embarkation/disembarkation activities of ro-ro ships
- management of the records of road haulers and terminal operators.

By managing the process of creating the loading/unloading lists, it will be possible to describe the list of ro-ro units expected to embark or disembark from the ship.

System users in the back-office component are profiled according to the following setting:

- operational users who introduce remote input via web interface (such as the registered haulier who enters/integrates data relating to his transport)
- supervisor users who perform data management and can intervene to modify/integrate data already written in the system
- administrator users for profile management, system configuration and parameterization.

3.2 Minimum Dataset and Information Acquisition

The minimum set of data necessary for the basic functionality of the EasyLog system consists of the following information:

- place of detection
- license plate (nationality + actual license plate)
- date and time of passage.

From an IT point of view, this set of information constitutes the unique key to identify an EasyLog data. The data can be acquired in different ways for each node, possibly even in several places within the same node, for example:

- gate in/gate out
- embarkation/disembarkation of the ship.

To this minimum dataset, the system allows to associate, even later, further information of interest such as vehicle length, damage detection, any ADR codes, etc.

Depending on the availability of information, three possible cases for data transfer are defined:

1. STANDARD CASE: the minimum dataset is known. The input information contains the minimum dataset and, in particular, the destination of the goods and therefore the destination node concerned. Once the input from the detection system (smart glasses, camera, etc.) has been acquired, the information relating to the node of destination is entered and a file is generated only for it.
2. BROADCAST CASE: the destination is unknown. Not being able to generate a unique identification flow for a single recipient node, a broadcast file associated with a minimum set of information is generated which remains in an "open" state and which is made available to all connected EasyLog nodes. When the destination is known, all files will be deleted except that of the destination node.
3. SPECIAL CASE: adding information. The system allows to update or integrate the information even after sending the data file to the destination node. In this case, a data transmission file will be prepared from the origin node containing the previous and additional data relating to the plate together with the "update" command.

Figure 3 illustrates the information flow considering the three cases.

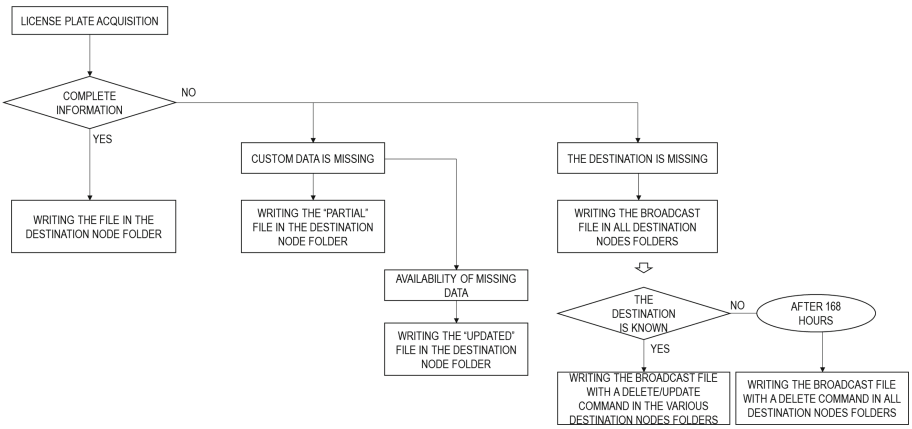


Fig. 3. Information flow. Source: Elaboration of the authors.

4 The Experimentation Area

The geographic context of intervention concerned five Tyrrhenian ports: Bastia, in France, and Livorno, Olbia, Portoferraio and Savona, in Italy. The five ports showed very different levels of automation and digitization. Some of them were already equipped with well-structured PCSs and terminal operating systems, such as Livorno and Bastia, whereas others lacked any IT managing system for rolling cargo, such as Portoferraio, Olbia, and Savona.

The choice of the specific configuration of the EasyLog local system was dictated by local needs, depending on the availability of physical spaces, integration with current

operating procedures, and the economy of operation and installation. The hard configuration was chosen for the ports of Bastia and Livorno while the virtual automation for the ports of Olbia, Portoferraio and Savona (Fig. 4).

For a description of the state of fact and the technological needs identified in the five ports, the interested reader can refer to [13].

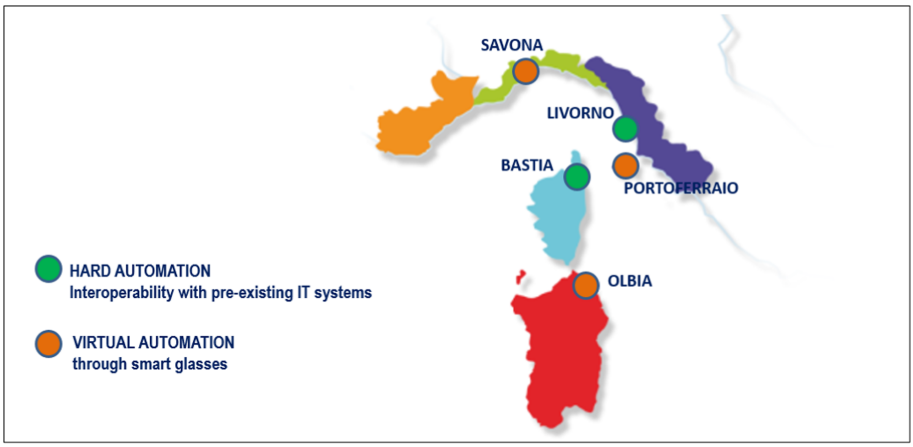


Fig. 4. EasyLog local modules. Source: EasyLog project

5 The Experimentation

The experimentation of the EasyLog integrated IT system was carried out in May 2021 in order to assess:

- the effectiveness of the system functionalities (advance notification of units arriving by sea at the port of destination, management of the records of road haulers and terminal operators, truck announcement)
- the effectiveness of the system to exchange data between the ports in the network using the EasyLog Connector
- the effectiveness of the innovative virtual gates operated through smart glasses to effectively manage gate-in/gate-out operations and boarding/disembarkation operations
- the interoperability of the EasyLog system with any IT systems (including any automated gates) already in place in the port.

It should be noted that license plate reading activities are typically carried out under controlled conditions with fixed cameras, with ad hoc optics and lighting. Given the innovative nature of the virtual gate operated through smart glasses and the lack of previous experience regarding its degree of accuracy, and also considering the variable nature of the scanning conditions that characterize its operations, the experimentation

also had to evaluate the aspects of accuracy and reliability of the system in order to introduce any corrections that would allow to optimize its performance.

The experimentation was carried out in two phases:

- Phase 1: virtual testing. A preliminary trial was performed in a laboratory environment by simulating the five port nodes, and related data acquisition and sharing
- Phase 2: real-world testing. A field trial was performed in situ at the five port nodes with the involvements of real port operators and transporters. The field trials were carried out in a first phase under standard conditions and in a second phase by operating in critical conditions through stress tests. In particular, two days of severe bad weather in the port of Olbia made it possible to test the operation of the smart glasses device even in critical environmental conditions characterized by pouring rain, gusts of wind and significantly reduced brightness.

The experimentation was carried out considering the four maritime corridors displayed in Fig. 5. Considering the maritime corridors in the experimentation was fundamental to allow the complete traceability of the information and logistic flow along the entire maritime corridor that connects the port of origin with the port of destination. The trial covered the entire process from the moment the haulier books access to port *x* to embark a semi-trailer destined for port *y*, until the moment the same semi-trailer is unloaded at port *y* and made available for collection by another hauler.

The users involved in the testing of the system were trucking companies, terminal operators and the port authorities involved, at different levels, in the activities of gate-in/gate-out, loading/unloading and delivery/collection of ro-ro units in the port:

- shippers reserve their ship voyages
- trucking companies announce the delivery and/or withdrawal of their semi-trailers
- terminal operators manage gate-in/gate-out and loading/unloading activities
- port security operators manage gate-in/gate-out at port gates.

By way of example, this paper describes the information flow that characterized the testing of the EasyLog system along the Olbia-Livorno maritime corridor. This corridor constitutes an interesting case example for experimentation purposes as it connects two ports that are very different from the point of view of digitization.

On one side of the corridor is the port of Livorno. Livorno is a terminalized multipurpose port with a high level of automation. It is already equipped with an advanced PCS, the so-called TPCS - Tuscan Port Community System, which facilitates the exchange of information between the multiple operators operating within the port (terminal operators, port authorities, customs agencies, forwarders, etc.), and with a port monitoring system, the so-called Monica - Monitoring and Control Application, which integrates a multiplicity of information sources deriving from applications or sensor nodes, to provide a series of value-added services to the port community.



Fig. 5. Maritime corridors tested. Source: EasyLog project

The implementation of the EasyLog system at the port of Livorno concerned its connection with the other EasyLog nodes through the Connector, and the digitization of a series of services previously digitized only for containers such as the arrival notice at the terminal and the registration of transit, embarkation and disembarkation for rolling goods, also allowing the optimization of related yard operations.

The experimentation at the port of Livorno involved the terminal LTM and its gate, named Galvani Gate, which is automated through a physical portal equipped with OCR cameras, and managed through its Gate Transit Security (GTS) system.

On the other side of the corridor is the port of Olbia. Olbia is not currently equipped with any telematic support for the management of the physical and information flows relating to Ro-Ro traffic, and access to its port area is manned by terminal staff. The implementation of the EasyLog system at the port of Olbia introduced gate automation through the creation of a mobile gate operated by smart glasses and the development of a back-office app that enables various functions: truck announcement, ship announcement, management of loading and disembarkation list, connection with the other EasyLog nodes through the Connector.

Below is a schematic description of the activities and actors involved in the testing of the system functions in the two ports of Livorno and Olbia.

Port of Livorno - Arrival of the semi-trailer by road and boarding on the ship to Olbia

Forwarder:

– Using the "Truck booking" form of the TPCS, enters the booking to embark a semi-trailer at the LTM terminal with destination Olbia and engages the trucking company to deliver the unit.

Hauler:

- Reserves the port slot for the delivery of the semi-trailer by completing the truck announcement using a wizard in six steps (1. terminal selection, 2. selection of the estimated time of arrival, 3. completion of the vehicle and driver information, 4. selection of the units to be delivered, 5. Selection of the units to be picked, 6. Confirmation of the summary).
- Completes the announcement by indicating the truck and the driver who will deliver the semi-trailer.

Gate Transit Security system - Galvani Gate:

- Records the transit of the semi-trailer at the port entrance through the OCR cameras.
- Makes the information available to the TPCS system.

Terminal operator - LTM:

- Gate-in the semi-trailer by verifying data, driver, and port of destination.
- Proceeds to board the semi-trailer.
- Declares the completion of boarding and departure of the ship on the TPCS.

EASYLOG Connector:

- Sends the cargo list of the incoming ship to the port of Olbia using the EasyLog Connector.

Port of Olbia - Arrival of the ro-ro unit by ship and departure by road

EASYLOG Connector:

- receives from the port of Livorno the loading list of the ship(s) arriving in Livorno from Olbia.

Back-office operator:

- makes available the forecast disembarkation list sent by the port of Livorno by displaying it on the smart glasses (the forecast disembarkation list coincides with the embarkation list of the port of Livorno)

Port operators:

- using smart glasses, the operator in the apron opens the disembarkation operations on the ship arrived from Livorno.
- using smart glasses, verify the received disembarkation list and confirm the ro-ro units actually disembarked.

Back-office operator:

– at the end of disembarkation operations, makes available the final disembarkation list of semi-trailers now available for withdrawal.

Hauler:

– using the "Truck announcement" service, announces its arrival at the port to collect the semi-trailer arrived by ship from Livorno.
– completes the announcement by indicating the tractor and driver who will collect the unit.

Back-office application:

– makes available the list of oncoming trucks for withdrawal.

Port security:

– using smart glasses, verifies and accepts the tractor for the withdrawal of the semi-trailer.
– using smart glasses, records the transit of the semi-trailer as it exits the port gate.
– declares the gate-out of the semi-trailer.
– as the trucks arrive in port, views the list of ro-ro units left in the yard and ready for withdrawal.

6 Experimentation Results

The EasyLog Connector was found to be effective in the exchange of embarkation/disembarkation lists between the port of origin and destination, proving adequate for the sharing of essential information for the purpose of optimizing port operations.

The experimentation has generally given encouraging results as regards the potential deriving from the use of smart glasses in the management of port operations. Some minor operational problems emerged related to the novelty of the product, which in any case did not compromise its good functioning and were indeed useful to introduce some precautions in use.

In the management of gate-in/gate-out operations at port gates and embarkation/disembarkation in the port apron, the smart glasses device has proved effective for capturing and recognizing the number plates of stationary and moving vehicles up to an average speed of 30 km/h (although peaks close to 50 km/h have been recorded). As for the perspective angle, the smart-glasses device managed to capture and recognize the license plate correctly, even with perspective angles of 40°. During boarding or disembarking operations, it was observed that when the operator is positioned sideways to the loading ramp of the ship, the license plates of the vehicles can be tilted in many ways with respect to the camera of the smart glasses. This aspect made it necessary to perform a calibration of the device before starting the plate detection operations to improve the

reliability of the recognition (the plate is still read but with a lower "confidence" of the result compared to the case of the calibrated smart glasses).

The device was also tested in various lighting conditions and during a thunderstorm. In both cases, the performance of the device did not undergo significant variations as the environmental conditions changed. Image acquisitions were made with stationary vehicles in a range from 25 to 7800 lx. In particular, the system correctly recognized the number plates of all vehicles both during the tests carried out just before sunset (average number of lux in the environment = 1200) and during sunset (average number of lux in the environment = 25). In case of rain, there was a range of variation between 100 and 700 lx. Similarly, the microphone for voice control was able to acquire voice commands without major problems, despite the noisy background that typically characterizes port activities. The only voice problem encountered was in the case of strong gusts of wind whose hiss made it difficult for smart glasses to recognize voice commands, a condition that was aggravated by the use of an FFP2[1] mask for COVID19 protection by the operator. This problem was solved by adopting a simple additional microphone (a mobile phone earphone) connected via a standard 3.5 mm jack audio cable to the device and placing the microphone inside the FFP2 mask.

Two terminal operators, three maritime companies and three port authorities took part in the experimentation. The involvement in the trial of the safety and security staff of the ports allowed moving and operating safely in the port area during the experimentation activity. At the end of the experimentation, the operators who took part in the trial were asked to express an opinion on the device tested and its functionalities. All the operators interviewed expressed a positive opinion on the potential use of the device in the port area. As for the usability of the smart-glasses device, it lived up to expectations. The operators found the device light in wearing and comfortable thanks to its articulated arm that can be adapted to the different needs of a field operator. During the trial, the operators were able to choose in front of which eye to place the display, the height and the distance of the display, and to rotate the display to move it away from the visual field when not used.

6.1 Limitations of the Research

The experimentation conducted was primarily aimed at testing the functioning of the proposed ICT system for the purposes of its operational feasibility. Although from a qualitative point of view the experimentation gave encouraging results regarding the validity of the proposed solution and its applicability to the operational port context, the limited number of tests carried out so far does not allow to provide a quantitative statistical evaluation of the reliability of the system. To this end, a broader experimental campaign is being planned, which envisages the direct involvement of at least three ports. The new experimental campaign will also provide for the recognition of foreign license plates and container codes and will evaluate the reliability of the system from a statistical-quantitative perspective through the assessment of various performance indicators (rate

[1] Personal protective equipment that prevents the user from inhaling aerosols, vapors and gases that are dangerous to health. It guarantees a minimum filtration of 94% and internal penetration of no more than 8%.

of correct recognition of license plates, reduction of the recognition rate in case of bad weather, correct recognition rate according to the transit speed of the vehicles at the gate, license plate reading speed according to the operator's position with respect to the vehicle, etc.).

7 Conclusions and Future Prospects

This study has described the experience of the EasyLog project, which designed, developed and tested an innovative ICT integrated system that enables the exchange of operational information in an orderly and secure way between five ports in the Tyrrhenian area. The developed system has three strong elements of innovation:

- differently from the existing ICT port systems developed as autonomous and closed systems, it can enable the interconnection of different ports, thus allowing the secure and orderly exchange of information, and improving efficiency, reliability and security in operations along the maritime transport chain
- it can overcome the barriers that typically hinder the development of shared ICT solutions among ports (a.o., different digital maturity levels, missing standards, lack of willingness to share data, etc.) through a structure that guarantees the autonomy of individual local systems while guaranteeing their interconnection through the so-called EasyLog Connector
- it can allow easy and flexible automation even in ports poorly digitized, or where economic or operational constraints make traditional gate automation complex, by introducing the innovative virtual gate created using smart glasses.

The proposed ICT integrated port system together with its Connector and virtual gates were tested in the five ports and along four maritime corridors to verify their functionality.

The Connector proved to be effective in the exchange of embarkation/disembarkation lists between the port of origin and destination, proving to be adequate for the sharing of essential information for the purpose of optimizing port operations. The experimentation gave encouraging results as regards the potential deriving from the use of smart glasses in the management of port operations. Some minor operational problems emerged related to the novelty of the product, which in any case did not compromise its good functioning and were useful for introducing some precautions in use. Given the challenging conditions of use and the experimental nature of the proposed system, the proposed solution turned out to be a good compromise between the following characteristics: usability, simplicity of operational flows, speed in completing scanning activities, and response times of user feedback.

Although a wider experimental campaign is necessary for the statistical-quantitative evaluation of the reliability of the system, the experimentation has confirmed the operational potential of the developed system and its applicability to the port context. The positive results of the experimentation pave the way for the future implementation of the system with the expansion of its scope of application. The enlargement of the EasyLog network with the inclusion of other nodes such as interports, backport logistics areas,

distribution centres, etc., could guarantee real traceability of all the salient moments of the movement of a rolling vehicle, allowing an approach to optimize the entire logistics chain, and no longer only the maritime branch.

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