Use of ICT for More Efficient Port Operations: The Experience of the EASYLOG Project

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Abstract. The 4.0 revolution in the shipping industry is growing fast and ports are requested to constantly innovate and evolve. Ports need to become not only smarter to implement more efficient, sustainable, and safer operations but also interconnected with each other. This paper presents the experience of the Easylog Project – Optimized logistics for ports and intermodal transport – funded under the Interreg IT-FR Maritime 2014–2020 program. Easylog aims to improve the mobility of rolling cargo between Italian and French regions by taking advantage of ICT technologies to increase the performance of intermodal transport chains and the overall quality of the services offered by ports. The project involves five ports in the upper Tyrrhenian area for which it proposes the shared adoption of integrated ICT devices for optimized and secure management of port operations between the operators involved in the cross-border (trans)port chain. The driving idea is to move from a non-integrated and fragmented management and control system of port events and flows to a common and connected ICT system. Easylog may represent a useful case study potentially replicable in many port contexts.

Keywords: Smart ports · Port integration · ICT · Gate automation

1 Introduction

Freight transport is no longer intended as a simple connection service between two areas, but as a key element of the entire logistics process [1]. The insufficient connection among operators and the lack of necessary information along the transport chain are widely believed among the main causes of delays in the shipment of goods, in the operation of ships and the management of port events [2]. In this regard, the desire to develop information and communication technologies (ICT) to support logistics operations and stakeholders' connectivity, has long been evident in the transport sector [3]. Digital-based technologies are now more than ever an element of absolute interest for developing the efficiency of port systems and intermodal chains [4, 5]. In particular, ports as essential gateways in supply chains need to integrate a variety of actors to coordinate traffic flows and related operations [6]. In a port, different operators and service providers must necessarily interact and exchange information and documents with each other. Such information may originate from a variety of sources, both internal (port authorities, port

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security, customs and inspection bodies, etc.) and external (shipping companies, trucking and logistics companies, shippers, maritime agents, etc.).

The adoption of digital technologies to improve the connectivity of the various stakeholders and the efficiency of operations has now become crucial for many ports. Information systems are recognized to facilitate communication and decision making in ports and enhance efficiency, reliability and security in operations [7]. The enlarging role of cooperation and information sharing, as well as the value of high-quality information for increasing the efficiency of port operations, are both extensively documented; see, for example, the studies by [8, 9]. It is also believed that digital transformation may help ports to compensate constraints related to inadequate infrastructures, capacity limits or accessibility problems [10].

Although with different implementation levels, several ports and stakeholders have now started technological upgrading [11]. However, it seems that to be truly effective, the various actors cannot simply adopt the technologies on their own but must interface with integrated platforms and services that make it easier to interact with the other stakeholders in the network [12]. Several leading ports, such as Hamburg, have already successfully tied multiple individual systems into a single interconnected platform. Furthermore, as supply chains are more integrated and connected, it becomes increasingly clear that stakeholders' connectivity must be guaranteed not only within the single port but also between the various nodes and actors in the transport network [11]. Several challenges characterize the development of shared digital solutions in the (trans)port community. Main problems may typically concern different digital maturity levels between actors, missing standards, and a lack of willingness to participate and share information [10, 13].

This paper describes the experience of developing a common and integrated ICT system for the optimized and secure management of information flows and port operations in five Tyrrhenian ports with different levels of digitalization. The ports analyzed are Bastia, in France, and Livorno, Olbia, Portoferraio and Savona, in Italy. The considered port context shows a lack of systemic vision which hinders the adoption of shared technological solutions along its transport chains. The general objective behind the design of the new system was to contribute to improving the mobility of rolling cargo (Ro-Ro) between the regions of the upper Tyrrhenian area by exploiting ICT technologies to increase the performance of the cross-border chains and the overall quality of services rendered by ports.

The framework of the paper is as follows. Section 2 introduces the application area and the five test ports while Sect. 3 describes the elements of fragmentation existing both in the road haulage sector and in ports which may hinder the adoption of shared ICT systems in the Tyrrhenian area. Section 4 presents the methodology used to design the new integrated IT system for connecting the five ports and illustrates its main features and functionalities. Some final remarks are in Sect. 5.

2 The Test Area

The geographical context of intervention concerns the maritime connections between the ports of 4 Tyrrhenian regions: Corse (France), Liguria (Italy), Sardinia (Italy) and Tuscany (Italy). The ports involved are Bastia, in France, and Livorno, Olbia, Portoferraio and Savona – Vado, in Italy. Figure 1 depicts the test area.



Fig. 1. Test area and ports involved.

The port of Bastia is the main port of Corsica region. It handles nearly 60% of the overall traffic volumes from/to Corsica, passengers and freight combined.

The port of Livorno is classified as a Core Port within the Trans-European Transport Network (TEN-T). It is a complex multipurpose port which handles a variety of goods: containers, Ro-Ro, liquid and solid bulk, new cars, cruises, ferries, forest products, relevant machinery, etc. The port of Livorno is equipped with an advanced Port Community System[1] which allows sharing data and information among a multiplicity of port and logistics actors involved in import and export flows (shippers, hauliers, shipping agents, control bodies, etc.).

The port of Olbia is one of the most important passenger ports in the Tyrrhenian area and a growing Ro-Ro commercial port. From an infrastructural point of view, it is divided into three areas: i) the main area is dedicated to Ro-Pax, Ro-Ro, and cruise traffic; ii) the internal area is reserved for pleasure boats; iii) the industrial area is used for bulk cargo and pure Ro-Ro ships.

The port of Portoferraio is the main port of the Island of Elba. It mainly ensures connection services between the island of Elba and the mainland. It is also a cruise and pleasure port.

[1] TPCS - http://tpcs.tpcs.eu/.

The port of Savona – Vado specializes in the fruit sector and consists of an advanced container terminal, a ferry terminal and an oil terminal. Of interest for the study is its ferry terminal, which ensures frequent connections with the Corsica region (up to 3 daily departures during the summer).

3 Background

The fragmentation existing in the Tyrrhenian area, both between the various transport modes and between the various territories, is believed to determine an increase in logistics costs as well as an insufficient integration of the peripheral and island territories in terms of territorial continuity and connection to Trans-European Transport Networks (TEN-T) networks [14]. Particularly, intermodal transport seems to be characterized by a lack of systemic vision on different scales: within the port, between ports, and between the various actors involved. The subjects involved in intermodal transport chains are not only diverse (they may include, a.o., logistics and haulage operators, port operators, port authorities, port security staff, shipping companies, etc.) but also characterized by different and often divergent needs and interests. Broadly speaking:

- port operators need to monitor the vehicles in the port for an optimal yard and berth management;
- port authorities need to monitor port events and supervise the port areas for security purposes;
- logistics and trucking companies need to speed up port operations, check the location of goods and respect delivery times;
- shipping companies want to efficiently manage loading/unloading procedures and related lists.

The road haulage sector is characterized by a strong fragmentation due to the high number of small- and medium-sized companies. As an example, of the 87,361 road haulage companies registered in Italy in 2018, more than 62,000 have less than 5 vehicles [15]. Such small companies can have limited opportunities to invest in innovation (both digital and non-digital), training, and networking. Conversely, larger companies make often use of digital systems for fleet tracking, control of consumption, monitoring of dangerous goods, etc. However, in most cases, such systems are developed in-house and not designed to interact with the other nodes and operators of the logistics chain.

As for the port sector, digitalization levels still differ heavily from port to port. Extensive use of traditional methods of document exchange and manual management of the entire gate-in/gate-out procedure is still predominant in many 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. Starting from early experiments in the late 90s, Port Community Systems (PCS) are spreading in several ports to enable the targeted and secure exchange of information between economic operators and public bodies within the port community [16]. PCSs are intended to optimize, manage and automates port processes, including authorization, administrative

and logistical processes, through the single entry of the data and paperless procedures along the logistics chain. The applied systems and procedures vary widely from port to port. In Italy, the Directive "Guidelines to homogenize and organize the PCSs through the National Logistics Platform" 20/03/2018 of the Ministry of Infrastructure and Transport has introduced the obligation for Port System Authorities to migrate their PCSs to the National Logistic Platform - NLP [17]. The NLP is defined as an open and modular hardware and software platform oriented to the management of logistics processes and freight transport which aims at creating the interport network system by allowing the different actors in the logistics chain to be connected, using a common digital language. According to the Directive, Port Authorities that comply with their obligations will be entitled preferential for access to national economic measures for the realization, management and implementation of their Information Technology Services (ITS). Although the change promoted by the Directive is ambitious, to date its level of acceptance in ports is very low and a high level of uncertainty surrounds its practical implementation: most ports are still implementing their own PCSs.

The lack of systemic vision translates into a poor efficiency of the entire cross-border transport chain: the lack or inaccuracy of information produces delays both in the shipment of goods and operation of ships, as well as difficulties in planning, managing and controlling port events. This results in low efficiency of the whole intermodal transport chain and lack of vision of the whole supply chain. Switching from a multitude of uncoordinated port management systems to a common and integrated one seems a necessary evolution for improving intermodal transport chains and the overall quality of the services offered by ports.

4 Methodology to Implement an Integrated ICT Port System

This study aims to design a system that allows the five ports to be connected, using a common digital language and overcoming the poor coordination between subjects. Such a system is designed to meet the following driving objectives:

- optimize the exchange of information in gate-in/gate-out activities to minimize the time required for documentary checks and ensure greater integration between the subjects involved and better plan of port activities;
- increase the security of port operations through the automated management of port gates and the continuous monitoring of port accesses;
- improve the productivity of the whole intermodal chain through the elimination of data input and related errors;
- improve truck-turn-around-times at the terminal by reducing the bottleneck effect of ports.

The development plan of the research consists of 4 main phases:

1. *Cognitive phase*: this phase is aimed at acquiring deep know-how on the port core processes connected to the cross-border exchange of goods in the five test ports (check-in, check-out, disembarkation/embarkation, management of parking areas, security checks) in order to identify critical issues and needs. Although the

processes are known in general, it is essential to detail the analyzes on the use cases of the territories under study. The analyzes allow acquiring knowledge regarding port procedures and associated information flows, ICT systems in use, subjects involved, operational and technological needs.
2. *Design phase*: definition of the functional requirements of the new system in terms of application and information services that respond to the operational needs identified. The new system is designed to be interoperable with the systems already in use in the ports and the new gate automation system.
3. *Implementation phase*: development of the IT architecture of the new system for the optimization of operations and information flows connected to the cross-border transit of goods between the five ports involved, and automation of the access gates at the five test ports.
4. *Experimentation phase*: training to operators for the use of the new system and in situ experimentation at the five ports. The test ports belong, in pairs, to the following traffic corridors: Olbia – Livorno, Bastia – Livorno, Bastia - Savona, Bastia – Portoferraio.

4.1 Cognitive Phase: Identification of Technological Needs

The cognitive analyzes were carried out through interviews with stakeholders and on-site visits at the five test ports. A summary of the state of fact and identified technological needs as emerged from the analyzes are in Table 1. The five ports show very different levels of automation and digitalization. Some of them are already equipped with well-structured PCSs and terminal operating systems (TOS), such as Livorno and Bastia, whereas others lack any IT managing system for rolling cargo.

It is worth noting that the success of integrated IT systems depends heavily on the number of stakeholders who will use it, as well as on their willingness to share information. The biggest challenge is to achieve a common understanding between the different parties involved whereby they agree to adopt such a new system [18].

Considering that parties have different and often divergent roles and interests, to be successful such a system must be able to guarantee the autonomy and benefits of all individual actors on the one hand and the connection between them on the other [19]. In the framework of the study, several workshops were organized in an attempt to establish a good collaboration among the key stakeholders and facilitate the achievement of a common understanding of the proposed system.

Table 1. State of fact and identified technological needs in the 5 ports.

Port	State of fact	Specific needs
Bastia	The Port of Bastia is equipped with a management system called Eris Liner and has a gate-automation system in the North area which detects the plates of the incoming tractors and trailers, their length, and any ADR code. The gate staff checks the travel booking and authorizes access	− extend the gate-automation system to exit gates; − introduce a yard management module to use the port aprons as efficiently as possible

(*continued*)

Table 1. (*continued*)

Port	State of fact	Specific needs
Livorno	The Port of Livorno has a gate-automation system which allows the detection of the vehicles at the port gates. It has advanced digital assets, including the TPCS (Tuscan Port Community System), which constitutes the unique interface towards the port and logistics community. The TPCS is equipped with a "VBS-Vehicle Booking System" module which allows the management of entry and exit reservations of vehicles from the port, to date limited to container traffic	− extend the VBS module to rolling cargo, in order to allow the automatic generation of the loading list, on the basis of: i) booking data received from the VBS, ii) gate-in data received by the gate automation system, iii) gate-in messages sent by the terminal, boarding messages sent by the terminal; − create interfaces for data exchange with the EASYLOG platform, in order to share data of interest for the other ports involved in the experimentation
Olbia	The Port of Olbia is not currently equipped with any telematic support for the management of the physical and information flows relating to Ro-Ro traffic. Access is manned by terminal staff	− introduce a monitoring system for port access, which can allow the control and monitoring of all incoming and outgoing vehicles; − introduce a yard management module
Portoferraio	The Port of Portoferraio is not currently equipped with any telematic support for the management of Ro-Ro traffic	− introduce a system for the control and monitoring of traffic flows for security and compliance reasons with Community indications
Savona	The Port of Savona - Vado has a high level of automation on the container front and no automation on the Ro-Ro side. The access gate of its Ro-Ro terminal is manned by terminal staff. The square is divided into two areas: pre-boarding and boarding. The incoming vehicles are directed to the pre-boarding area, if in possession of a ticket, otherwise they are directed to the ticket office Freight traffic is all accompanied and there is no apron management in terms of parking allocation	− introduce a system for reducing documentary errors and delivery times and facilitating security operations. As for the latter, a computerized data flow that allows correct preventive information (currently the error rate of the lists is 15%) would speed up related operations

Several technological, economic, operational and commercial criticalities emerged during the analysis. Particularly, the main challenges seemed to concern:

- the different availability of input data (from trucking operators, terminal operators, port authorities, shipping companies, etc.);
- the well-known resistance [20] opposed by some stakeholders in the supply chain to share part of the information requested;

- the different operating modes existing in the ports and terminals involved;
- the diverse state of the art and technology in the five ports examined;
- the presence of different trades managed within the sample ports: accompanied and unaccompanied freight traffic, mixed Ro-Pax versus pure Ro-Ro traffic, presence of only residual freight traffic volumes compared to passenger volumes (such as in Portoferraio), etc.

The very different situations, endowments and needs detected in the five ports lead to the need to customize the automation equipment of the gates and the management system on a case-by-case basis, in order to be able to carry out a more adherent and functional experimentation to the individual cases.

4.2 Design Phase: Definition of the Functional Requirements of the New System

The driving principle of the design phase was to build a system that could potentially become a "standard model" for communication between ports, primarily for rolling cargo but with the possibility of further expanding its application to different types of cargo. The basic functionalities of the system have been developed according to the following criteria:

- satisfaction (at least partial) of the needs detected in analyzes and interviews;
- ability to exchange data between the five ports in the network;
- future opening to additional ports currently not included in the test;
- use of open and extensible standards in the future;
- interoperability with the ICT systems already in use in the port, if any;
- interoperability with the new gate automation system;
- need to leave a functioning IT infrastructure even after the end of the project. The infrastructure should not be based on centralized supports, such as central servers or databases, to be maintained by third parties.

The basic modules of the EasyLog system are defined as follows:

- module for managing the pre-arrival notification through ship travel bookings;
- gate-in/gate-out automation module (reading and recording of truck license plates, ADR codes, length, etc.) to identify and record each entity entering or leaving the port area;
- gate management module for security purposes (access to the port is allowed when a ship booking exists);
- yard management module for accompanied and unaccompanied Ro-Ro traffic;
- mobile module by means of personal digital assistants (PDAs) for the management of vehicles in movement in the yard;
- damage control module;
- data exchange module.

Each port in the network can activate one or more of the previous functions. Each function is customized according to what is already in place and the specific local needs. From a technical point of view, the system is designed to ensure input resilience and dataset scalability. The former allows different data input possibilities depending on the hardware environment available in the port while the latter leaves open the possibility of implementing future functionality extensions while maintaining backward compatibility.

The system is designed according to a modular and scalable structure in which the five different port modules dialogue with each other through the so-called Easylog connector (Fig. 2). The Easylog connector is defined centrally and constitutes the heart of the exchange system, intended as a set of rules for data exchange, formatting and availability. Each port has its own customized EasyLog module which can exchange data not only with the different actors in the node (hauliers, port authorities, shipping companies, terminal operators) but also with the other port nodes in the network. Each local module consists of a software component for data processing, storage and exchange, and a hardware component (automated port gate).

As regards the software functionality, the system allows:

- the terminal of destination to know the composition of the incoming cargo in terms of type and number (or linear meters) of vehicles, grouped by ADR class, to timely and properly organize port spaces and activities;
- the ports to reconstruct the origin and destination of the goods starting from the data collected by the automated gates;
- under reasoned requests in case of disputes on damages, to provide the terminal operator with the recorded images of the visible sides of the trailer when accessed to the port, indexed by plate number and access date/time;

The hardware component of each local module coincides with the automated gate for the identification of trucks entering or leaving the port. The developed gates are based on OCR Technology (Optical Character Recognition) that converts visual data to digital data. A truck drives through an OCR access facility, where truck details are captured and stored in the system database. Basic functionality of the Easylog automated gates include:

- reading of the truck license plate;
- reading of any ADR codes;
- detection of vehicle length and capture of images for damages detection;
- management of other passing vehicles (service vehicles, employee vehicles, passenger car traffic, etc.).

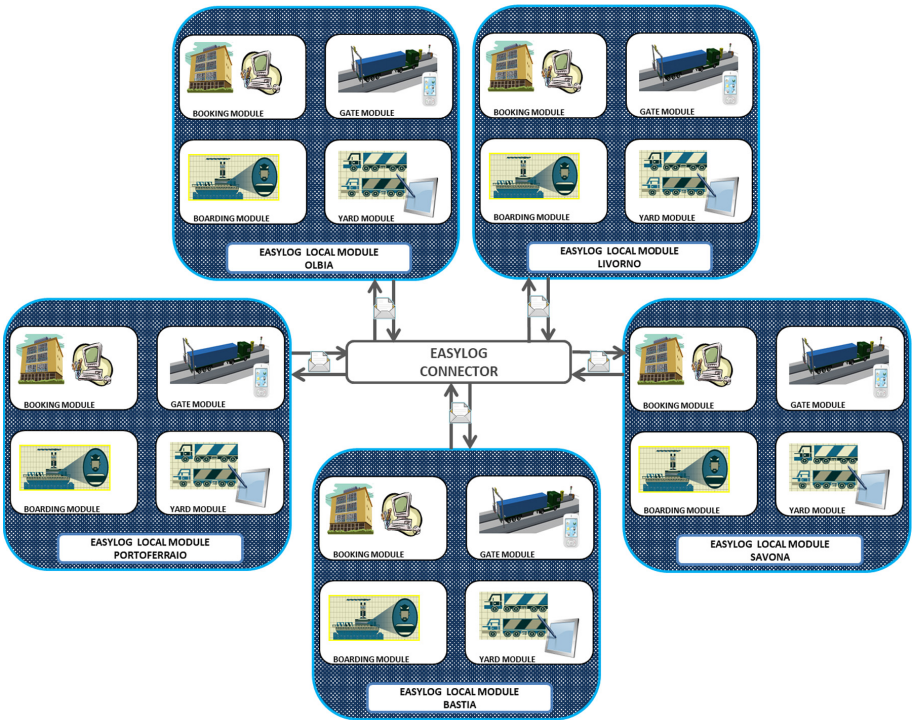


Fig. 2. EasyLog system.

The working principle is that the data (truck license plate, length of the vehicle, etc.) received through the OCR devices are transferred to the Easylog system and matched with the data already in the database.

The variety of situations and needs encountered at the five ports has offered the interesting opportunity to experiment with different systems and automation levels which can meet the needs of a wider range of ports. Depending on the existing local situation, the Easylog gates are implemented according to two levels of automation:

- hard automation – installation, over the entrance and exit gates, of classic physical portals equipped with OCR cameras, entry and exit barriers, sensors, etc.;
- light automation - creation of more flexible and economic "virtual" gates realized by means of PDAs and wearable OCR smart glasses for augmented reality to be used by trained personnel.

The choice of the specific configuration has been 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 has been chosen for the ports of Bastia and Livorno while the light automation for the ports of Olbia, Portoferraio and Savona.

At the time of writing this paper, the implementation of the five gates is underway in the five ports. Both the Easylog system and its automated gates are going to be tested in the coming months to assess their applicability and effectiveness.

5 Conclusion

This paper has presented the experience of the Easylog project which designs and implements an ICT system common to five ports in the Tyrrhenian area for the optimized and secure management of processes and information flows between the operators involved in the cross-border transport chain. The Easylog system is designed according to a modular and scalable structure in which the five local modules dialogue with each other through the so-called Easylog connector. The main innovative aspect proposed by Easylog concerns the systemic implementation of cutting-edge services and tools and their integration and interoperability aimed at activating synergies for the development of a cross-border community of port logistics. The Easylog system, synergistic and integrable with any IT system already in use in ports and with the new gate management system, proposes advanced and integrated technological devices to support both information and operational aspects. The system can allow coordinating the connections between the five ports in the area with the implicitly expected result of improving cross-border mobility and encouraging the development of multimodality between the Tyrrhenian regions, also in order to reduce road congestion by concentrating traffic on maritime routes and to achieve better cohesion between the territories. As a future development of the research, the potential integration of the Easylog system with other platforms will be studied in an effort to embrace a more holistic vision of supply chain digitalization.

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