Port-City Shared Areas to Improve Freight Transport Sustainability

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Abstract. The purpose of this work is to propose a methodological framework to evaluate the reuse of areas located close to the port as "retro-port", in order to reduce the externalities caused by Ro-Ro freight terminal operation and the burden of freight deliveries in urban areas. In this regard, an analysis of the main variables involved in this process is presented, with reference to terminal traffic, terminal capacity, accessibility to the port and freight handling infrastructures. The results of this research constitute the base to support and improve urban logistics activities, rethinking the use of elements and areas that characterize the port and its surroundings. These findings pave the way for further research related to the design and dimensioning of retro-port and the realistic implementation of an urban consolidation centre.

Keywords: Roll-on Roll-off · Urban consolidation centre · Maritime freight transport

1 Introduction

In recent years, maritime transport assumed a relevant role in city planning, moreover in the case of port-cities which are exposed to several externalities due to both operations in the harbour and increase in road transport caused by handling operations in the hinterland [1]. The importance of maritime traffic made that in the past the major industrial areas were installed near the ports, in order to facilitate the transport of raw materials and finished products.

In port-cities, nowadays, such spaces lost their original functions, acquiring a new great potential of transformation due to their closeness to the city and the port and becoming a unique opportunity to redevelop highly degraded or marginal areas: the redesign of these areas with a view to reconciling both the needs of the city and the port represents the opportunity to improve the sustainability of their relationship, making their coexistence possible [2, 3]. This push of sustainable regeneration cannot ignore the logistic needs imposed by the commercial activities of the port, which on the one hand require effective connections with the logistics centres and on the other aim to reduce the terminal operations times to guarantee a rapid delivery of goods in the urban territory.

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In this context this work frames the possibility of a reuse of large abandoned areas located near the port (with the creation of a so-called *retro-port*) as new shared logistics spaces that allow a reduction of the externalities connected to the maritime transport of goods. The aim of the paper is to provide with a realistic proposal for the regeneration of abandoned areas: a framework for the planning of a retro-port with urban logistic functions. The framework will be designed for a complete planning of the new facility, in the view of realizing a port-based distribution centre. The proposal will be applied to the case study of Catania and its port and in particular of a former industrial cement production plant adjacent to it.

The remainder of the paper is organized as follows. Section 2 will discuss background of the study with the analysis of the related literature. Section 3 will illustrate the different steps of the methodology, including the conceived framework. The framework will be applied to the case study of Catania in Sect. 4. Finally, conclusions will be presented.

2 Ports as Distribution and Logistics Centres

Ports are important and fundamental transport nodes in the supply chain because they play a critical role in the effective and efficient management of product and information flow [4]. The Port Service Quality constitutes a measure of the satisfaction of port customers, shipping lines and cargo owners and it is influenced by several factors. First, the port terminal capacity is the baseline to assess its potentialities. With reference to Ro-Ro terminal capacity, different methods can be found in literature to analyse it [5]. They are generally related to the waiting time over service time (W/S) [6, 7]; berth occupancy rate [8] and total turnaround time [9, 10]; both simulation [11–13] and analytic models can be used to estimate terminal capacity [14, 15]. However, the failure or unreliability of port services may also depend on other factors related to the transport infrastructures to access the port and the presence of additional services that can help to improve port capacity. In fact, ports undertake a variety of activities: loading/unloading cargo by vessels; providing value-added services such as labelling, packaging, cross-docking; acting as warehouse and distribution centres, and others [16]. Shipments located in the port area are considered most valuable by ports, because they are more integrable in the value chain. In this context, the advent of cross-docking represents a successful strategy to improve logistic operations and reduce the storage space needs, with positive and sustainable effects, allowing ship-owners to optimize the use of their assets while the terminal gains from the provision of value-added services. Among the good practices, there are the Ports of Gothenburg [17], Norrköping [18], Newark [19] and Santos [20]. It is possible to use the combination of cross-docking with a warehousing, in order to stage the goods, moving them from supplier to storage to customer practically without any handling except for truck loading [21, 22]. In the case of port cities, the location and construction of a warehouse in an area close to the port is a key element. In this direction, the regeneration of retro-port areas could act on four main aspects [23]: (i) urbanization of abandoned private areas; (ii) new job opportunities; (iii) change from the paradigm "port-city-industrial areas" to the new paradigm "port-city-logistic retro-port" [24]; (iv) opportunity for Public Private Partnership (PPP) actions.

3 Methodology

3.1 Problem Formulation

Ro-Ro transport developed a significant potential, especially in Europe with the concepts of "Short Sea Shipping (SSS)" and "Motorways of the sea" project, created by the European Commission in order to offer an efficient maritime service as a valid alternative to other types of transport systems. To make SSS competitive, times for loading and unloading cargo at terminal must be significantly reduced, considering the frequency of loads arriving at a terminal and the port terminal capacity. An intervention on the logistics chain of sea freight transport can be a fundamental solution to improve the capacity of the terminal itself and, consequently, improve the efficiency of the SSS.

In this view, in case of low capacity of Ro-Ro terminal in port-cities, we propose the use of abandoned areas located close the port in order to (Fig. 1): (i) expand the spaces supplied to the Ro-Ro terminal; (ii) provide the port and the city with a Urban Freight Centre, allowing the dispatchment of the goods with destination (or origin) in the city centre; (iii) reduce the congestion due to freight heavy vehicles that transport goods between the port (urban), the logistics centre (suburban) and in the city centre.

The design of the new retro-port should go along with the study of the port context, according to the following steps:

- analysis of port traffic and terminal capacity,
- analysis of transport infrastructure to access the port,
- analysis of related infrastructures (e.g. freight centre),
- design and dimensioning of retro-port: Ro-Ro terminal and UCC characteristics

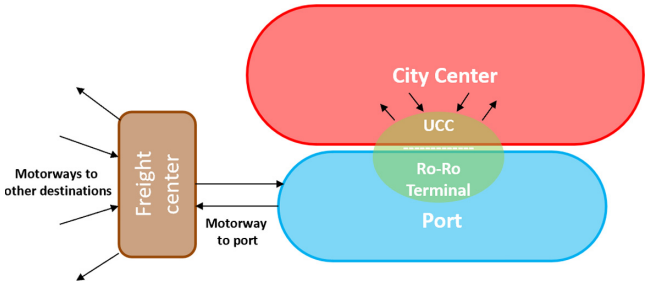


Fig. 1. Framework for the reuse of marginal areas (in green) shared between the port and the city (Source: Our elaboration). (Color figure online)

3.2 Analysis of Port Traffic and Terminal Capacity

The first step to take is the analysis of global port freight traffic, in order to understand the role of Ro-Ro transport within port logistics. If this role is of primary importance, priority policies can be adopted to encourage its operations within the port.

Ro-Ro terminals are characterized by a short stay of the goods in the terminal spaces: dock and yard are connected so that the vehicles that are unloaded from the ship

(or should be loaded) can move easily and in a short time; however, the impossibility of stacking the CTUs (Cargo Transport Units) translates into a greater need for space, which is often a weak element of the Ro-Ro terminals. After leaving the yard, vehicles leave the port through the gates, where a series of bureaucratic checks and procedures are provided to allow them to continue towards their destination. The issue of capacity and location on site inside the terminal is one of the most important, as most CTUs arrive before the ship departs. Furthermore, upon arrival of the ships, it takes a certain amount of time to unload the goods, while the CTU waiting for boarding must be parked in a safe area. Conversely, as for the CTUs that disembark from the Ro-Ro ship, they do not immediately leave the terminal and therefore need to be placed in a storage space. For all these reasons, one of the productivity and efficiency indices in Ro-Ro port is precisely the time spent by vehicles inside it: more time means occupied spaces and therefore a general waste of time which translates into economic loss. The frequency of trucks arriving at a terminal (demand) is one of the main criteria for terminal dimensioning: for an existing port, optimization or expansion studies of the terminal area can be carried out in order to increase efficiency. Other variables to be taken into account are the inadequate number of terminal gates and customs control units, the number of vehicles arriving at a terminal, the ship's capacity, the distance between the terminals and bunkering local traffic in relation to the connection of the terminal.

3.3 Analysis of Transport Infrastructure to Access the Port and Intermodal Chain Related Infrastructures

Ports are strategic access "gates" to urban areas and reference territories. Therefore, accessibility is a key concept for urban planning [25–27] and, in particular, for port design and management [28]. According to [29], the concept of accessibility applied to a port has significant potential in determining and explaining its operational, economic and competitiveness performance: a more competitive port should always be associated with a higher level of accessibility.

In the logistic chain of freight transport, the transport network, the geographical constraints, the available modes of transport, times and costs are among the most important criteria for choosing the route to take. Freight accessibility is characterized by the linear transport infrastructures (roads, railways), internal/external to the port system, the port's position in relation to the surrounding area, the main transport nodes and the transport infrastructures with logistic functions. In this context, the port is intended as a node of a transport network: a port is competitive if it has an efficient transport network that allows an easy and quick entry-handle-departure of goods; in addition, intermodality with other modes of transport (roads, railways, inland waterways) must be ensured to guarantee adequate connections with the hinterland.

Several infrastructures can be part of the freight logistic chain involving the Ro-Ro terminal. Examples could be:

- Warehouses: unimodal infrastructures operating as storage facilities (i.e. Warehouse), which do not necessarily involve joint operations.
- Freight/logistic centre: Areas involving integrated operation, such as: filling, emptying, consolidation, handling, stocking and other services by typology of

goods and forwarding of wagons for block trains. In particular, in the case of urban areas Urban Consolidation Centres (UCCs), which are logistic facilities placed in the outskirts of a city [30], play an important role to improve city logistic. In UCCs, freight is consolidated and then distributed to the receivers of goods by a different operator. This type of logistics centre will be the one considered in our study.

- Intermodal Freight Terminal (IFT): or transfer point is a place equipped for the transhipment and storage of Intermodal Transport Units (ITU), connecting different transport modes (e.g. road, rail and waterborne) [31]. They usually include vehicle parking and facilities for loads handling, providing not only transport-related activities but also national and international logistics and distribution.

3.4 Design and Dimensioning of Retro-Port: Ro-Ro Terminal and UCC Characteristics

Ro-Ro Terminal Characteristics

The success of the integration of Ro-Ro traffic into logistical transport chains depends on a optimal design of the Ro-Ro-terminal itself; of course, seaside, terminal and land-side external factors play a relevant role in design criteria.

As in every terminal, it is possible to sub-partition the Ro-Ro terminal spaces in 3 subsystems [32, 33]:

- Berthing and stevedoring area, consisting of: manipulation areas for cargo handling; short-term storage area and traffic lanes for towing-units;
- Storage area for long-term storage of semi-trailers with traffic lanes for towing-units
- Delivery and receipt area, with gates and parking for trucks with semi-trailers

The CTU must complete several steps before reaching its destination [14]: (1) ticket booking and collection; (2) check-in; (3) entering the terminal gateway; (4) border control formalities; (5) custom clearance; (6) waiting at loading site; (7) boarding the ship; (8) transportation phase; (9) disembarkation; (10) queuing at storage site; (11) border control at arrival; (12) custom clearance at arrival; (13) exiting terminal. Considering the three terminal areas, the main optimal operating features of a Ro-Ro terminal can be assumed the following [34]: (i) optimal scheduling of vessels: fixed departure times and appropriate sailing frequencies; (ii) minimum space consumption and obstacles of vehicles cargo handling (e.g. reduced loading and unloading equipment); (iii) effective traffic management inside the terminal (e.g. use of appropriate signage for circulation and parking); (iv) separate internal traffic with dedicated lanes for delivery/pick-up.

UCC Characteristics

The UCC works as an interface between outbound and inbound freight transports, in order to serve a whole city or parts of it, also by offering value-added logistics in terms of more flexible delivery times, stockholding and unpacking larger consignments [35]. According to [36] and [37], UCC represents one of the most studied city logistics initiatives because it has the potentiality to reduce negative effects associated with freight distribution, with both the social and environmental dimension, by giving an

alternative to current distribution systems. Furthermore, the integration of intelligent technologies allows to obtain cost-efficient and resource-efficient results, with an impact not only on environmental sustainability targets but also on citizens' wellbeing and financial sustainability [38–40]. The services offered by a UCC can be several: nightly and off-peak deliveries; request delivery time and frequency; stockholding; pre-retail services; ordering processes; waste and return management; etc. Therefore, appropriate ITS systems are required for an optimized management of goods and also physical spaces for their organization and handling. The warehouse constitutes a fundamental component of UCC: it is a logistic structure that allows to adjust the differences between the incoming flows of the goods, i.e. those coming from suppliers or production centres, to the outgoing flows, i.e. the goods that are sent to production and sale.

The benefits the UCCs can provide are linked to two different aspects. The first one is represented by the reduction of negative effects from distribution of goods, because by consolidating goods close to the city, it is possible to have shorter delivery distances and freight vehicles entering in the city with higher load factors, with the direct consequence of the reduction in their number [41–43]. The second one regards benefits aimed at different stakeholders. Authors highlighted the importance of stakeholders' engagement in several ways to structure transport decision-making processes and identify improvement solutions towards sustainability [44–48]. In particular, through the implementation of UCCs, citizens and local can benefit from attaining a more attractive city with fewer freight vehicles [41].

The UCC can be considered an efficient and effective solution to be implemented in an urban area, whether it is able to achieve the following results and implications [49]: (i) Increased cost efficiency of potential customers; (ii) Reliable deliveries; (iii) Reduce number of freight vehicle in urban area; (iv) Reduce freight handling by workers; (v) Provide high customer service; (vi) Generate revenue; (vii) More storage.

Designing a Port-City Shared Space

The constant increase in maritime traffic (and also in the Ro-Ro segment) means that ports must adapt their infrastructure to increasing number, dimensions and speed of vessels; for example, in the case of Ro-Ro terminals, in order to achieve greater time performances, the terminal should be provided with shipborne and dock side ramp systems for loading and unloading processes. One of the major obstacles to these improvements, especially in the case of ports that are located within cities and near the historic centre, is essentially the lack of space. Furthermore, the increase in port traffic also affects the increase in road traffic, affecting the network reliability and with consequent environmental, social and economic externalities [50, 51].

With this in mind, this study proposes the conversion of abandoned areas near the ports with the multiple purpose of: (a) increase the spaces of the port terminals dedicated to the transport of goods; (b) provide the city with an urban logistics centre that will reduce the impact of freight transport on the streets of the city centre.

Based on the characteristics identified in the two previous sections, the new area must therefore have:

- A portion dedicated to the typical port operations of the Ro-Ro terminals and in particular to those that take place far from the seaside area of the terminal (tipically storage, delivery and receipt area);
- A part dedicated to the typical logistics operations of an urban logistics centre and its warehouse (e.g. departure/arrival of unpackaged goods; packaging in load units) (Fig. 2).

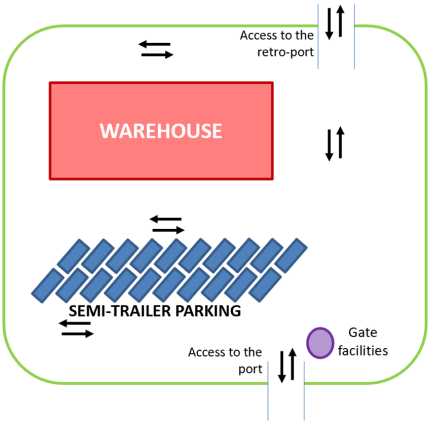


Fig. 2. Framework for the design of a retro-port with Ro-Ro facilities and logistic centre (Source: Our elaboration).

4 Application: A New Retro-Port in Catania as Strategic Asset for City Logistic

4.1 Case Study

Catania is a city located in the south of Italy and it is the second largest city of Sicily, with a population of more than 300.000 inhabitants only in the urban area. Thanks to its strategic position in the region, Catania is the main industrial, logistical and commercial centre of Sicily [52]. The harbour is a fundamental resource for Catania's economy. Located in the centre of the Mediterranean Sea, the Port of Catania, with a total surface of 615,000 m^2 used for goods storage yards, holds a variety of different activities: a tourist and commercial port (with national and international connections provided by major shipping companies) and a transport interchange with rapid connections to motorways, rail services and the airport. Moreover, being an historic Port, it is sited in an area of greatest contact with the city, deeply inserted in the urban context of Catania and specifically in the area of the historic city centre. The unplanned distribution of these heterogeneous functions and activities results in overlapping and intersecting flows of freights/passengers, with the direct consequence of flows that exceed road capacity and the generation of criticalities for vulnerable users [53, 54]. For this reason, it is fundamental to identify the main urban, landscape, architectural and functional

components of this area with the aim of resolving the major problems inherent in the commercial activities of the Port while considering the port-city relationship.

The Port of Catania has a total area of about one million square meters, with 470.000 m^2 covered by land areas, 280.000 m^2 dedicated to goods storage and 26 operating docks with an overall length of berths of 4.200 m. It extends in the North-South direction with the entrance of the Port facing south. It is closed to the east by the outer pier *Molo Levante*; to the south it is bordered by the pier *Molo di Mezzogiorno* and by a newly built area called *Nuova Darsena*. The eastern basin is identified as the "new port" and has a polygonal shape, while to the east of it, separated by the *Sporgente Centrale* there is the "old port", mainly used for fishing activities (see Fig. 3, left).



Fig. 3. Terminal Port of Catania (Source: Our elaboration from Google Maps), left; Aerial view of intervention area, right (Color figure online)

In recent years there have been significant developments in containers, Ro-Ro and Ro-Pax ferries volumes, thanks to the location of the Port and its connection with the regional road and motorway network, with the airport and the Bicocca train station and the realization of the *Nuova Darsena*. With its 1.100 m of operational docks, 120.000 m^2 and 5 new berths, *Nuova Darsena* supplies a precious commercial lung for the storage and handling of containers, Ro-Ro and Ro-Ro/pax traffic which has so far occupied the historical part of the port in close contact with the city. With reference to the total tons of goods (i.e. rolling stocks, containers, parcels, dry and liquid bulks), the Sicilian Port has enlivened altogether a volume of more than 2,9 million tons of goods (+3.5 points with respect to the last five years). In this scenario, the Ro-Ro commercial activities positively increased, with 296.990 units of rolling traffic; considering the container sector, it is less developed respect the others, but also increasing thanks to the connections with transhipment hub-ports, with a total movement of 63.179 container units; cruise traffic isn't negligible, reaching a 313.138 passengers (Port Authority, 2019).

One the most relevant factors to consider regarding the Port of Catania is its closeness of the area to the functional and historical heart of the city. The Nuova Darsena is already over-saturated and it is difficult to plan its expansion in urban areas.

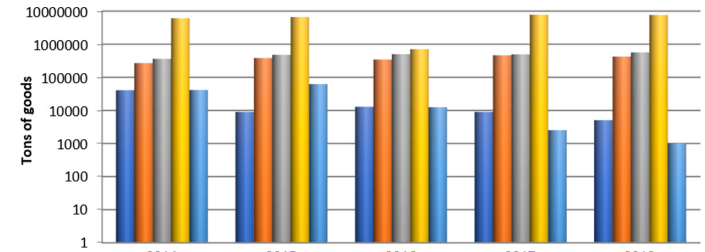
For these reasons, with reference to the commercial activities of the Ro-Ro terminal (light blue portion shown in Fig. 3, right), the possibility of having a supporting area would be useful to increase the capacity and improve the effectiveness of these activities. This hypothesis is considered of extreme interest because it would allow flexible delivery times, stockholding and unpacking larger consignments. Furthermore, the proximity to the city centre would allow benefits from different points of view: economic (less travelled kilometres and delivery times), environmental (lower emissions), social (decreasing congestion level in the centre). In this regard, right adjacent to the Ro-Ro terminal area there is a former industrial cement production plant (red portion shown in Fig. 3, right). This abandoned area, called in Italian "Cementeria", could be taken under consideration for a regeneration proposal, through its conversion as a retro-port with urban logistics function. In this regard, next section will provide a more detailed analysis focusing on the relevant characteristics of the Port of Catania (e.g. traffic terminal and related infrastructures) in order to provide a proposal for the design and dimensioning of the retro-port.

4.2 Proposal

Ro-Ro Traffic and Terminal in Catania

The Port of Catania is the first in Sicily as far as the movements of "dry goods" is concerned, thanks to an accurate planning and the use of equipment to work with competitive costs and high productivity.

Ro-Ro is a special type of vessel with special ramps in order to make the loading and the unlading of vehicles and cargo easier and more convenient. Over the years, several technological advancements have taken place in these carrier ships and resultantly, there have emerged into various types of Ro-Ro vessels, e.g. ferries, Ro-Pax, Ro-Con (Rolling Stock + Containers), barges, conventional ships with aft ramp, PCC (Pure Car Carriers) and PCTC (Pure Car and Truck Carriers). Specifically, the latter 2 are characterized by the transport of cars (and heavy construction site vehicles) on ocean routes, transporting an average of 200 trucks, divided on about a dozen internal bridges. Among the Intermodal Loading Units (UTI) most used for the transport of goods between the Mediterranean port (and therefore also for the port of Catania), there are swap bodies and semi-trailers. In particular, about the port commercial activity, it emerged that the Port of Catania is mainly characterized by an increasing Ro-Ro traffic, that is one extra order of magnitude compared to the tons of goods handled through containers. By elaborating the annual statistics collected by the Port Authority of the Eastern Sicily Port System, Fig. 4 shows the different percentage of freight traffic components. From 2014 to 2018, in terms of handled tons, the quantity of liquid bulk and other goods decreased, whereas the container traffic, Ro-Ro and solid bulk increased. Data elaboration (referring to the year 2018) allows to affirm that Ro-Ro constituted the 88.5% of the considered traffic, followed by the 6.5% of containers, 4.9% of solid bulk and the remaining low percentage represented by liquid bulk and other goods.



	2014	2015	2016	2017	2018
Liquid bulk	40701	8995	12880	8971	5047
Solid Bulk	269344	382836	342275	458902	423732
Container	359586	476544	497986	491836	564141
Ro-Ro	6080289	6627359	708110	7755589	7623470
Other goods	41271	62046	12406	2529	1016

Fig. 4. Tons of goods for different freight traffic components of Port of Catania, 2014–2018 (Source: Our elaboration from Port Authority data)

An analysis of Ro-Ro terminal capacity has been conducted in a previous study developed by the authors [55], which showed that one of the main critical issue regards the size of the terminal, even though the recent opening of Nuova Darsena. The allowable number of CTUs which can use the storage site depends on several variables, e.g. the time of arrival of the ship at the terminal, the number of CTUs disembarking from each docked ship, the average storage time at a terminal site and the part of CTUs using parking at the terminal. The general intensity of CTUs processed at the gateway was determined by considering the number of gateways of the terminal and the time necessary to realize the entire process of unloading the single CTU. Then, from the application of a Poisson law it was estimated that the reliability of the terminal is insufficient because not all the CTUs can be accepted and that the average queue time outside the gateway is excessive. Even more in detail, the number of CTUs that use the Ro-Ro terminal is 600, and the percentage of CTUs remaining in the terminal following the landing was deemed about 90% of the total, i.e. 540 units. Considering that the Ro-Ro terminal of Catania has 450 spaces for CTUs, it implies that the terminal spaces are not sufficient for handling the current Ro-Ro traffic. These findings demonstrate the necessity of a further area to accommodate growing volumes of Ro-Ro cargo and to improve port operations in the Port of Catania.

Intermodal Chain Related Infrastructures in the Case of Catania

The Port of Catania is characterized by a high "centrality" due to its proximity to nodes of the intermodal network system, such as the central railway station, the freight yard, the dry port, the agri-food market, the airport, the "Circumetnea" urban railway station, Bicocca intermodal railway station, the industrial area and its several logistic companies (see Fig. 5).

Bicocca intermodal station is the main freight station, located inside the industrial area of Catania. This terminal has an area of 32.000 m^2, 4 tracks which have a total length of 2000 m and it is serves by rail links to the southern (i.e. Lamezia) and northern Italy (i.e. Milan). The interport of Catania-Bicocca represents a large intermodal complex in the south of the city of Catania. It is divided into two poles about a kilometre and it is divided

in two parts: the "Intermodal Pole" located near Bicocca station and the "Logistic Centre" inside the industrial area. The area dedicated to the Logistic Centre occupies about 166.000 m^2, of which approximately 46,000 m^2 belonging to the "Parking Area" functional lot. It provides the allocation of internal and external infrastructures for logistics operations (e.g. warehouses, service building and parking areas for heavy vehicles).

Finally, always located in the industrial area of Catania, there are numerous logistics centres specialized in offering logistics and freight movement services. As emerged from the descriptions of previous infrastructures, these centres have a considerable distance from the city centre and consequently from the port. Therefore, it often happens that the goods arriving at the port are carried out by heavy vehicles in the industrial area. Subsequently, after logistical operations, the goods directed to the city centre are transported back to the port, with obvious economic and environmental disadvantages. Hence, it arises the importance of an area close to the port to be used as a retro-port, supporting commercial operations of the Port of Catania.

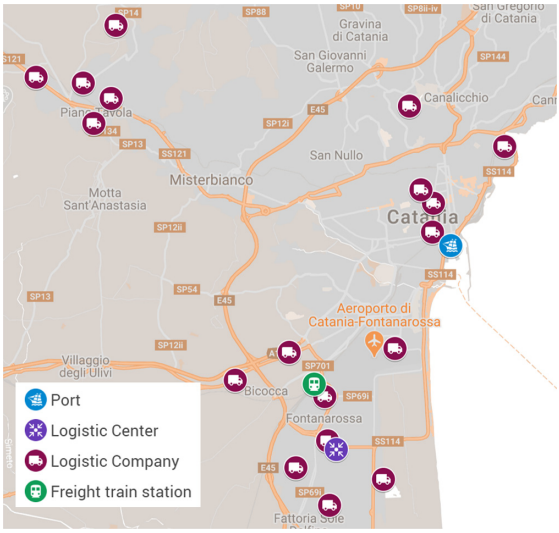


Fig. 5. Map of intermodal chain related infrastructure.

Transport Infrastructure to Access the Port of Catania

The Port of Catania has two main access gates. The first one is located in the northern part and it is intended for the entry of private vehicles and pedestrians; from this gate the port is accessed by an urban arterial road (SS114) which is already very congested, due to the south-north traffic crossing the of the city. The second access is located in the southern part of the port and it is reserved for the entrance of heavy commercial vehicles; in particular, the urban road relating to this access (the same SS114), during the days of departure of the ships, is highly congested because the usual traffic of crossing the city intersects the one related to the commercial vehicles entering/leaving the port. The connection between the port and the interport is guaranteed by the same

road 114, which reaches the industrial area of the city, where most of the logistics operators are present. This area is also connected to the city of Catania via the *tangenziale* ring road, a highway that circles the city without crossing it.

Design and Dimensioning of the New Retro-Port
First of all, in order to guarantee an easy connection between the port and the retro-port, the area should be connected directly to the Ro-Ro terminal through either an underpass or an overpass that would cross the arterial road 114, the current only physical separation between the port and the cement plant. Following the integrated scheme in Fig. 4 of the retro-pot, the following minimum characteristics for the new retro-port in Catania emerge: (i) an area dedicated to the parking of semi-trailers that could host at least 90 vehicles more; (ii) a warehouse for city logistics; (iii) an area dedicated to gate controls. The evaluation of the dimension of the facilities' equipment would depend on an estimate of the percentage of Ro-Ro traffic in the port of Catania which, rather than continuing to the usual destinations, would be diverted to the new UCC. Knowing the volume transported in a semi-trailer, the number of rolling stock that arrives in the port per year and the possible working days of the warehouse in a year, the total volume worked per day in the warehouse can be estimated. From this, an average daily warehouse's capacity could be estimated. In the same way, it is possible to calculate the number of ramps needed to allow the semi-trailers to unload the pallets. These could be assessed through assumptions related to the number of hours of work per day and the time required to unload the semi-trailer: in this case, a number of average ramps needed in a day to unload a previously obtained volume of goods can be found.

5 Conclusions

Port city often have to deal with externalities due to port operation and the related traffic congestion [56]; the trend of such issues would inevitably grow together with the constant increase of maritime traffic and the consequent importance of Ro-Ro traffic for freight delivery. In port city, close former industrial zones are often marginal areas; their reuse can be a good opportunity to improve sustainability of port operations. In this paper a framework for the design of a port-city shared space is provided with a twofold aim: improving port operation and enhancing city logistic. The design of the retro-port is based on the evaluation of port's traffic and terminal's capacity, in order to guarantee a good efficiency of terminal operation. It is also proposed to use the new available spaces and the proximity to the city to support urban logistics activities, in order to reduce congestion and externalities caused by heavy vehicles travelling between the port, the logistics centres, and the urban area. The application of the methodology to the Catania case study shows design feasibility and its ability to support port operations during rush hour. Further research should focus on the economic feasibility of the Urban Consolidation Centre and policies related to its organization, both in terms of actors to be involved and entities that should manage its operation.

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