Methodologies for Sustainable Development of TEN-T/RFC Corridors and Core Ports: Workers Mobility between Urban and Port-Related Areas

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Abstract. This paper concerns the passenger mobility generated by a SEZ area near to a core port connected to Trans European Network-Transport (TEN-T) and Rail Freight Corridors (RFC). The SEZ area and the port represent the places where workers perform their daily activities. Transport connections between the port and the corridor can be a bottleneck that produces externalities for the areas around. This paper examines spatial and temporal connections identifying strategies to achieve sustainability according to the UNs Agenda 2030.

Keywords: Smart ports · TEN-T corridor · RFC corridor · SEZ · passenger mobility · sustainability

1 Introduction

According to UNCTAD classification, ports evolve towards different generations. The first generation includes ports inside the cities. The second generation includes the industrial ports. The third one includes container ports with increasing levels of added value (AV) produced by the freight movements and transformations processes [1, 2]. Industrial areas near to the third-generation port contribute to increase the AV [3, 4]. A specific typology of industrial area is the Special Economic Zone (SEZ) that supports the production of added value (AV) linked with economic activities [5]. SEZs are regulated by special conditions for operating enterprises [6]. Accessibility and smartness, in terms of integration between transport, energy and ICT [7–9], are the main SEZ's characteristics to contribute to increase the production of AV [10], linked with economic activities [11, 12].

This research concerns the ports belonging to the Trans European Network (TEN-T) and their bottlenecks that could constitute a limit for freight and passenger mobility. In relation to freight mobility, bottlenecks regard physical barriers and/or administrative obstacles, that produce inefficiency on the free flow of goods, people, and information, with reference to the gateway ports [13]. For instance, in Italy in 2014, the average

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times for export are 19 days that are greater than for Germany and Belgium (9 days) and Holland (7 days) [14].

At the same time, the SEZ and the port area generate workers mobility because they represent the job daily activities' places. The problem regards the interactions between transport and economic systems [15]. The paper produces more insights about the workers mobility deriving from the interactions between port and the external territory. Urban and transport planning can regulate these interactions individuating solutions at short and long terms, with the aim to increase the sustainable people mobility according to the UN's sustainable Development goals [16]. Transit Oriented Development (TOD) [17] and Mobility as a Service (MaaS) are possible solutions for improving sustainable transport connections. In this context, the paper offers two kinds of research's contributions:

- an analysis of the phenomenon related to external interactions between a port and the surround area, focusing on the people mobility component;
- a methodology to analyse and improving spatial and temporal connections of third generation ports with a transit network.

The specific case study is the Gioia Tauro port in the south of Italy, a core node of TEN-T inside the Scandinavian – Mediterranean Corridor (TEN-T 5) and a gateway for the Rail Freigth Corridor (RFC) 3 with a SEZ area. The port has different potentialities, but it presents some limitations in the spatial and temporal connections with TEN-T and around territories. The proposed methodology can support port authority and, more in general, public and private decision makers involved in the development process of a third port generation.

After this introduction, the paper has three sections. Section 2 recalls the general problems related to the territorial and mobility interactions, with a specific reference to the case SEZ areas near to a port of international relevance. Section 3 describes the methodological approach followed in this paper for studying spatial and temporal connections. Section 3 reports the main results obtained from the methodology's application for the connection of Gioia Tauro port with Scan Med TEN-T and RFC3 Corridors. Section 4 discusses the results with final remarks and further developments of this research.

2 Territorial Activity and Mobility

This paper focuses the territories characterized by the presence of a port of third generation belonging to the TEN-T and with a SEZ. The specific case regards ports located outside of an urban area (Sect. 2.1). The working activities produce AV but, at the same time, they generate daily mobility between residential and port related areas (Sect. 2.2) (Fig. 1).

2.1 Urban and Port Related Activities

The study context is a particular case of the general spatial economic transport interaction (SETI) process [18]. The economic activities are performed in the port related areas. The

workers, living in residential areas distant from the port, performs daily trips that use available transport connections.

The SETI process implies the necessity to individuate urban planning solutions, including urban regeneration, new town, or smart city approaches [19]. Urban planning regulates the equilibrium between the economic sustainability, measured with the increasing of the AV, and social/environment components for workers and inhabitants [20]. Strengths related to the presence of the port and SEZ areas have to be considered with weakness of the hinterland [21]. Transport infrastructures and services connections can be considered a first step of the regeneration process.

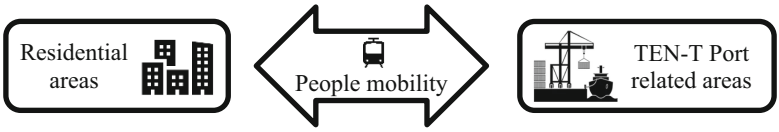


Fig. 1. People mobility generated by port-territory interactions.

In this specific context, an integrated transport-territory planning could balance the advantages, related to the generation of added value (AV) for the entire area [19] and disadvantages, related to externalities produced by workers' mobility. This means to achieve the following objectives: 1) to enhance the competitivity of the port in the international supply chain; 2) to improve efficiency of the productive processes inside the SEZ and their potentialities for export; 3) to limit the effects produced by the potential urban sprawl due to the distances between the residential and port related areas. Urban regeneration is a possible way for defining spatial and temporal connections that facilitate freight and people mobility.

2.2 Workers Mobility

Sustainable mobility actions have a decisive role to improve workers mobility [22]. Optimal passenger's mobility services increase connections and therefore accessibility allowing people to perform their daily activities with the minimum quantity of economic resources (time, energy, monetary costs,…).

A high level of accessibility is a necessary condition to increase the quality of life in the city. A possible planning tool aimed at increasing the accessibility of the urban territory is the SUMP [7, 23, 24]. The SUMP defines a set of integrated (material and immaterial) infrastructural and managerial measures to pursue sustainability objectives. The indications about the transport system can be accompanied by urban regeneration solutions in terms of (Fig. 2):

- material infrastructures, including the regeneration of the urban environment, production facilities and business services;
- immaterial infrastructures, including the redefinition of urban technologies supporting for civil uses (ICT, energy, waste, water, …);

- management and services, including organizational aspects related to mobility, energy and sustainable monitoring.

This paper focuses on the management and services issues with an attention to mobility services for people's mobility. In the following chart, this issue is named "urban mobility regeneration".

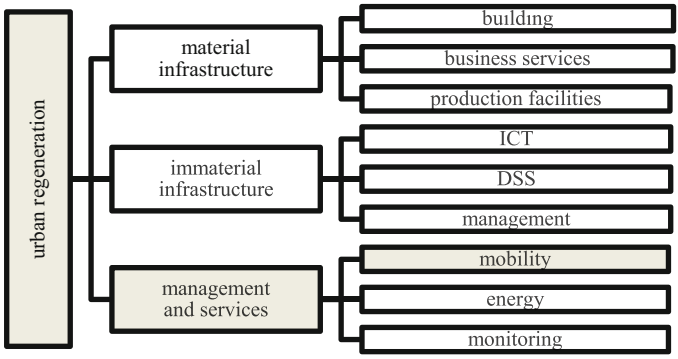


Fig. 2. Urban mobility inside the urban regeneration process.

Urban regeneration renews the passenger mobility services, improving spatial and temporal connections between the port, the SEZ area and the TEN-T corridor. It can be considered a trigger of the entire urban regeneration process.

Transit Oriented Development (TOD) is a possible short-term solution to start the urban mobility regeneration process. It is a consolidated approach to improve territorial-transport interactions around a transport node [17, 25, 26]. It consists of matching urban places (buildings, and public space) and people's needs generated by their daily activities (e.g., jobs activities in the port). At medium – long term, the TOD approach must be integrated with the Mobility as a Service (MaaS) concept [27–29] that combines emerging ICT potentialities and Transport System Models (TSM). ICT technologies allows the collection of data and information about mobility needs. According to the paper's focus, TOD and MaaS are integrated to respond the current and future people mobility needs generated by the port's activities. By considering the options that produces the minimum level of externalities, MaaS evolves towards the Sustainable Mobility as a Service concept [30, 31].

3 The Proposed Methodology

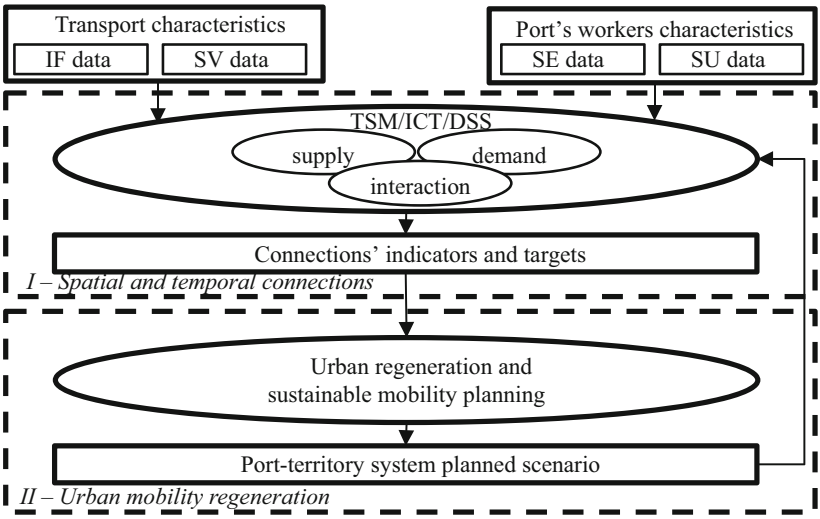
Urban regeneration process can be implemented following the proposed methodology, specified for analyzing and improving people's mobility of between the SEZ area and the surrounding territory. The methodology is organized into two steps (Fig. 3):

- the first step analyses the current performance level of spatial and temporal connections between the port and the surrounding territory, in relation to the workers mobility needs (Sect. 3.1).

- with the results of the first step, the second step defines urban regeneration strategies inside a sustainable mobility planning (Sect. 3.2).

3.1 Spatial and Temporal Connections

This step is aimed at analyzing the current level of space and temporal connections between the port and the residential areas.



IF: Infrastructures; SV: Services; SE: Socio Economic; SU: people mobility survey
TSM: Transport System Models; ICT: Information and Communic. Technol.; DSS: Decision Support System

Fig. 3. Methodology to improve port-territory workers mobility.

Spatial connections are constituted by the road and railway infrastructures that link in the space the core port with transport network. Often, a spatial connection is a necessary but not sufficient condition to ensure the port's accessibility and the sustainable mobility. It is necessary to analyze and improve the temporal connections ensured by the collective transport services and their characteristics (in Fig. 3 SV data). Transport network design models can be used integrating data obtained from ICT [32], Transport System Models (TSM) and Decision Support System (DSS) [33, 34] (Fig. 3).

Monitored data must include socioeconomic characteristics (residential uses, SE data) of the and habits of port's workers (origins, desired arrival/departure times, modes, SU data) [31] aimed at individuating the travel choices of port's users.

3.2 Urban Mobility Regeneration

Step 1's results (Sect. 3.1) identify accessibility gaps and sustainability issues related to passenger mobility generated by the port terminal and SEZ activities.

TSM support the transportation planning process [24] aimed at individuating interventions for removing bottlenecks and improving spatial and temporal connections [35]. The interventions have different temporal horizons.

At short term, it is possible to modify transit services (e.g., new itineraries and schedules), with the same level of transport infrastructures, according to the temporal demand profiles. This requires the integrated use of ICT and TSM, by adopting a Sustainable Mobility as a Service (S-MaaS) in terms of transport network design [36] to consider the user's behavior [33], transport supply [34] and their mutual interactions [30]. Typical examples of interventions are integrated electronic ticketing system, information systems and demand management.

At long term, it is necessary to consider the interventions that modify the material asset of transport infrastructures. Each intervention produces direct and indirect effects on transport and territorial systems that can be estimated and compared with the indicators and relative targets defined by the Agenda 2030 [16].

4 Case Study

The methodology presented in Sect. 3 has been applied for Gioia Tauro, the core port of the Scan-Med core corridor (Fig. 4). This is a third-generation port with a SEZ instituted by the Italian Government [37]. SEZ zone covers an area of 402 hectares where it is possible to perform industrial and service functions [3, 38, 39]. The port location implies workers daily mobility around the territories of the Calabria region, in the south of Italy.

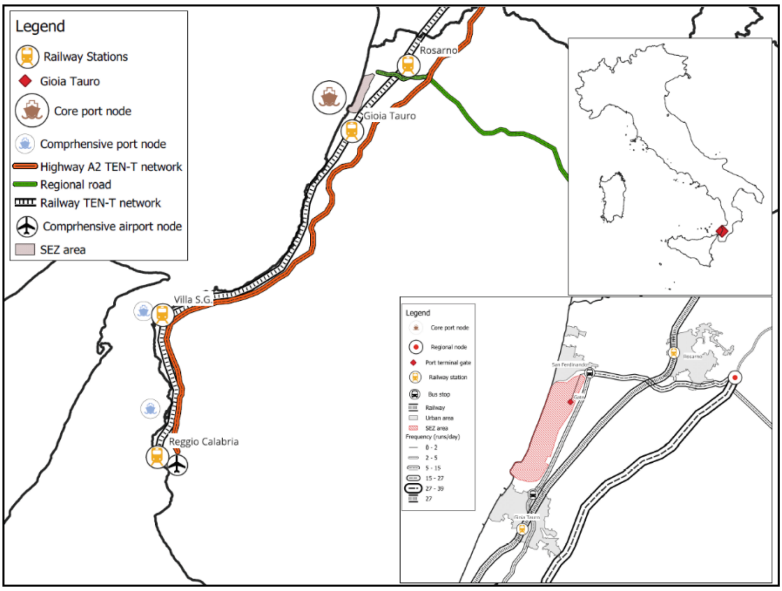


Fig. 4. The study area: main infrastructures belonging to TEN-T Scan Med Corridor.

In the current configuration, the port produces container movements with a limited AV. This is due also to the lack of services and transport connections. The port is located near a territorial area characterized by a high rate of unemployment [40]. The study area is near to the territory named "piana di Gioia Tauro", inside the metropolitan city of Reggio Calabria. The nearest urban areas are Gioia Tauro, Rosarno and San Ferdinando. Port and SEZ areas have great economic potentials to improve export processes and for economic development of the Calabria region [41–43].

The port amounts around 4,000 workers that daily operate inside the terminal area [44]. In the future, the port's activities and relative production processes could increase. The "piana" territory is characterized by an urban sprawl that produces accessibility problems. The economic development of the SEZ area will generate a major number of workers (about 7,000) and then a greater number of daily trips between the port and the surround residential areas.

The following sections illustrate the application of the proposed methodology (Sect. 3). The analyses of the current situation (step 1, Sect. 4.1) support the definition of interventions at short and long terms (step 2, Sect. 4.2).

4.1 Spatial Connections

As far as road connections are concerned, the Scan Med corridor includes the highway A2 Salerno-Reggio Calabria, with the main junctions Rosarno and Gioia Tauro. Others relevant road infrastructures are the SS18 for north-south connections, the transversal motorway SS682 that link the SEZ area with the Jonic side of Calabria region, thus the SS 106 Reggio Calabria – Taranto. Concerning rail connections, the Scan Med corridor includes the national conventional railway Salerno – Reggio Calabria. The two railway stations nearest to the core port are Gioia Tauro and Rosarno. The nearest airports are "Aeroporto dello stretto", in the province of Reggio Calabria and Lamezia Terme International airport, in province of Catanzaro).

4.2 Temporal Connections

Temporal connections are analyzed at national, regional and local levels, and in relation to considering collective transport services by rail and road. Table 1 reports the daily frequencies and connecting travel times with the two airports (Reggio Calabria and Lamezia Terme). The total number of railway services is 27. The great part (74%) has a regional relevance.

As far as concerns road collective services, the extra-urban connections of "piana" and the rest of the Calabria region are analyzed. The Calabria region is divided in:

- metropolitan, distinguished in the Reggio Calabria metropolitan area into "piana", southern area (south), the Jonian area (east);
- regional including the other parts of the Calabria region (north).

Table 2 reports daily frequencies and connecting travel times for all Calabria territories. The total number road collective services are 39, regarding metropolitan services (90%), connecting the south territory (41%), the "piana" (31%) and the east territories (18%). Travel time related to bus mode has been estimated with an average speed of

Table 1. Railway connections (source: www.trenitalia.it)

Territorial reference		Number of companies	Daily frequency (bidirectional)	
			n	%
Regional	North	2	4	10%
Metropolitan	Piana	1	12	31%
	South	2	16	41%
	East	2	7	18%
Total			36	100%

RC: Reggio Calabria airport; LT: Lamezia Terme airport; GT: Gioia Tauro port.

90 km/h for Nord and South areas, while an average speed of 60 km/h for the East and Piana side has been assigned. Note that total number of daily road services connecting the area is relevant (Table 2).

Table 2. Road services connections in the study area (Gioia T., Rosarno, San Ferdinando)

Territorial reference	Daily frequency (bidirectional)		Travel times (minutes)	
	n	%	GT-RC	GT-LT
Regional/local	20	74%	53	62
National	7	26%	43	42
Total	27	100%		

Services are available at few stops but located at a not walkable distance from port related areas. In fact, Fig. 5 shows the actual layout of connections and their daily frequencies in a working day. Most part of travel services is along the highway A2 from South territory and on the railway TEN-T network. Note that it exists only a 10% of the total analyzed runs with a stop inside the port area. Besides, frequencies are not specific for port employees' temporal needs; hence, on Sundays are residual (Fig. 3).

4.3 Indicators and Targets

The results of the step 2 are the indicators' values of spatial and temporal connections (Table 3). As regards the spatial connections, Table 3 reports the spatial distances between the port gate and railway stations, road junction, bus stops. Moreover, it is reported the distance between the port terminal and Reggio Calabria and Lamezia Terme airports. It is specified that the distances between port gate and bus and train stops are longer than, respectively, 400 m and 800 m which represent the targets indicated by the national SUMP Italian guidelines [37].

As far as concerns the temporal connections quality, depends on the differences between transit timetables and port employees' temporal needs. The highest values of

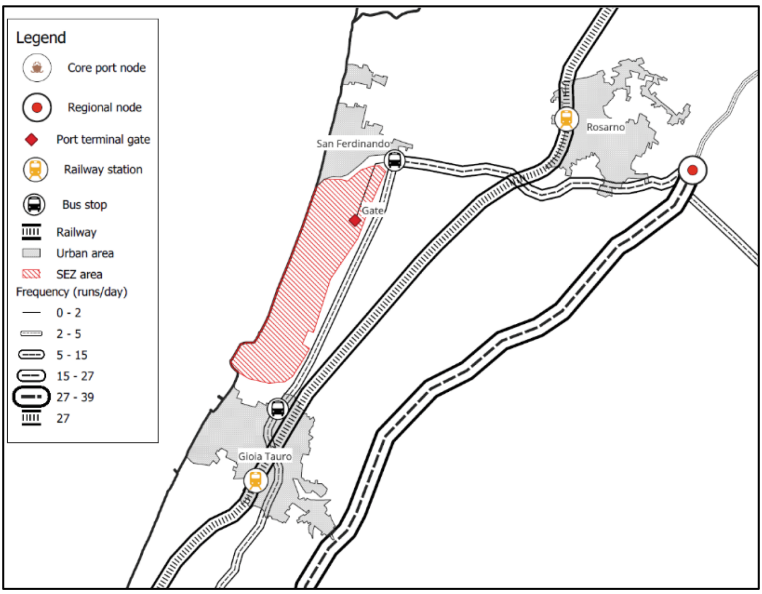


Fig. 5. Current quantities and territorial distribution of the spatial and temporal connections

Table 3. Distances between the port's gate and nearest stops for each mode (km)

	Rail	Road	Bus	Air
Gioia Tauro	12	10	4	–
Rosarno	7	10	4	–
San Ferdinando	–	14	–	–
RC, LT airports	–	–	–	77

daily frequencies reported in Table 1 for rail and road connections are scheduled in stops distant from the port's terminal.

Demand analysis shows that only 5% of workers declare that they choose railway mode. Consequently, it is clear that the interaction demand-supply is unbalanced.

4.4 Urban Mobility Regeneration

The current limits support the individuation of material, immaterial and organizational interventions. Figure 6 reports the three above mentioned intervention areas aligned to the classes reported in Fig. 2 for a long-term scenario (Sect. 2.2).

Material interventions at short term regard cycling and walking paths for improving last mile connections; at long-term, collective transport green infrastructures for connecting residential (Gioia Tauro, Rosarno and San Ferdinando) and port related areas and TEN-T corridor.

Management interventions at short term concern optimization of existing transit services. At long term, it is possible to integrate management and immaterial interventions implementing the S-MaaS approach and electrification mobility. All the solutions above described will have to be on target with guidelines and provided rules specified in the Sect. 3.2.

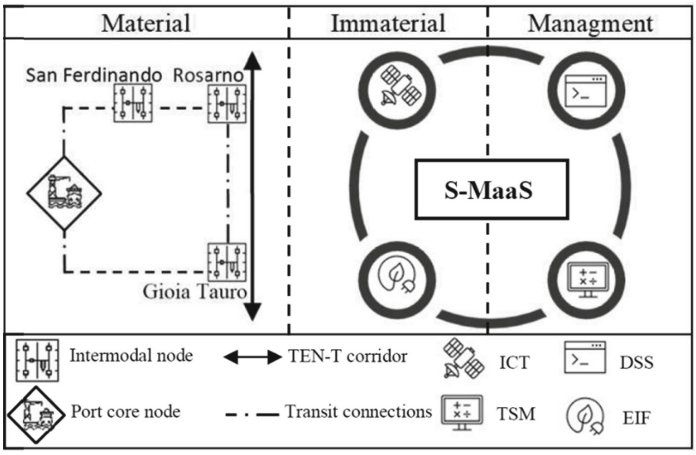


Fig. 6. Long term scenarios for spatial and temporal connections

5 Discussion and Final Remarks

The analyses presented in this paper show the necessity to further investigate the issue related to transport connections between nodes and links of TEN-T network, by focusing on the passenger mobility. The goal is to better understand the phenomena that produce negative impacts produced by the presence of a terminal dedicated to the movement of large quantities of goods in a territory.

This paper has focused on core ports, SEZ areas and hinterland relations. These specific territories represent a pole of attraction for the people's mobility because they constitute the workplaces of a significant number of employees who work in the port and in the SEZ area. The port interacts with the external territories and, in some cases, produces negative externalities in terms environmental impacts.

The results of the analyzed case study show that the growth of the port of Gioia Tauro has not been accompanied by mobility management policies aimed at guaranteeing the accessibility of the port in a sustainable way.

The people's mobility is unbalanced on private modes, and this produces congestion and negative impacts. According to the research's objective of this paper, the proposed methodological approach supports the investigation of the disconnection level between the core port and TEN-T corridors by means collective transport services.

The quantitative analysis of disconnections produces inputs for defining mobility management policies, within a wider transport planning process aimed at increasing sustainability.

The paper has limitations related to a more detailed analysis of the mobility needs of the people who interact with the port. Two main research directions are possible: to enhance the estimation of effects deriving from the territory-transport planning at short and long terms; to evaluate the realization of new high capacity transport line that connect urban and port related areas.

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