Inland Port Areas for Optimal Networks Management in Genoa: From Planning Issues to Artificial Intelligence

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Abstract. The application of digitalization and artificial intelligence to the field of infrastructural networks shows broad advantages: the improvement of the data collection quality, the works carried out in more precise environments with a relative lower incidence of discrepancies, reduction of the times of execution. All this, considering the need to make the management of regional and multi-regional transport more efficient, in accordance with the territories and their requests, in a cooperative perspective as much as possible. This is the approach recently promoted by the National Recovery and Resilience Plan PNRR and in particular in the funded Raise Ecosystem "Robotics and Artificial Intelligence for Socio-economic Empowerment", based in Genoa (IT). Within the Ecosystem, in Spoke 4 "Intelligent and sustainable ports", the aforementioned themes find ample space and new life for tackling the needs already claimed for a long time by the port clusters in the Liguria Region and, in general, in Italy. The RAISE approach proposed shows how to decline together social and technological issues, as its complexity requires. Specifically, in this paper, the strategic topic of ancillary inland port areas for the management of port operations (night parking areas, pre-gate areas, buffer areas and Special Logistics Zones) is explored as a fundamental tessera of a Western Liguria port planning system, integrated in its physical aspects related to urban planning and dematerialized data flows.

Keywords: inland port areas · artificial intelligence · strategic planning

1 Introduction

In recent years, the advancements of Information Communication Technology were undeniable. Big Data, Machine Learning and the Internet of Things are the most popular topics in both industry and research [1], and considerably waited by territorial bodies for their potential applications in planning and transport.

In particular, as far as port and infrastructures sectors are concerned, great expectations are addressed towards digital and robotics implementations. These for two fundamental reasons: the increase of safety for workers at risk exposition and the improvement in sustainability (economic, social and environmental) for operations and worksites [2, 3].

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Nevertheless, as shown in Fig. 1 (the green box is referred to Airports and Ports), real experimenntations are poor and at a partial level of maturity [4].

On the contrary, from the territorial institutions point of views, the added value constituted by digitalisations and artificial intelligence for engineering and constructions is well known and considered as promising. Speaking about Italy, one of the most popular feature of the Country -as a whole- is the National priority given to ports' performances, which were -for ages- drivers of innovations and competitiveness within their regions.

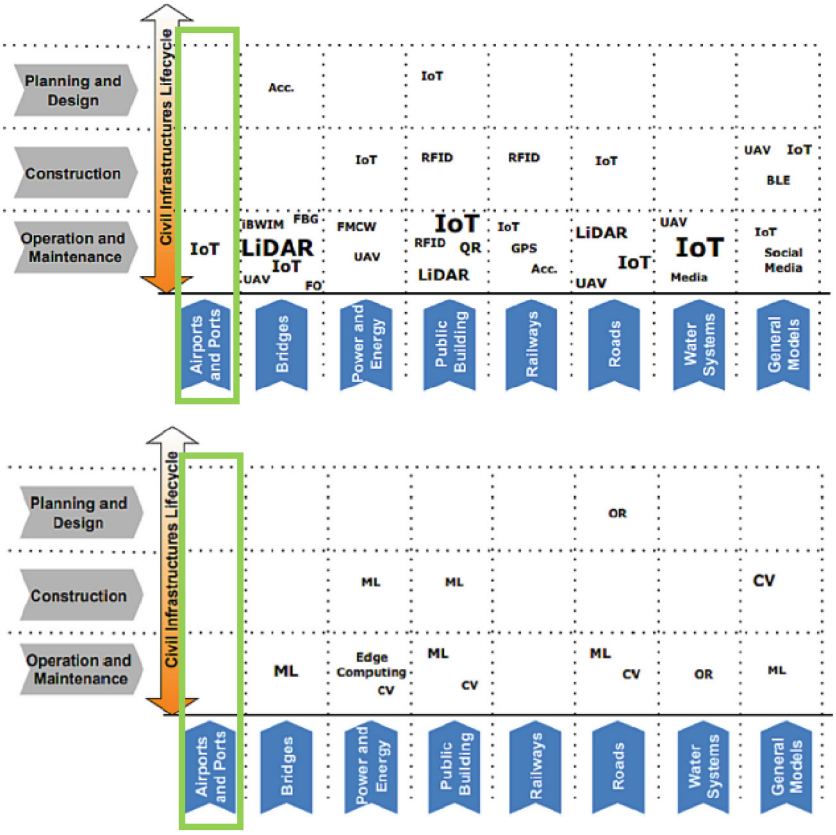

Fig. 1. Map of data acquisition technologies and data processing technologies across infrastructure domains and lifecycle (the content of the green box is referred to "Airports and Ports") (Elaborated from [4])

As a very dinamic context, ports' communities look at tecnologies potentials with a dual mentality: from one hand, dematerialization can cause possible enumployment rates in certain sectors, but, from the other one, the improvements due to acceleration, rationalisation and optimisation of flows, mansions and times are indisputable and strictly connected to global competition rankings (in wich nobody would like to be left behind) [5–7].

Regarding Italian ports positioning in the global scene, Genoa is the most important one, not only because it is the first in terms of tons of goods, but also because plays as the reference point of the productive North-West of Italy and has a long-lasting culture in fact of maritime studies [8].

For the purpose of the paper, Genoa port is an interesting case, because its Port System Authority (Western Ligurian Sea, from now on AdSP) drew up an innovative Strategic Planning Document in which "physical" land and transport planning actions were accompanied by an evident interest towards "digital" models applied for intermodality [9].

Starting from the EU Communication 395 "Ports: an engine for the growth" (2013) [10], which emphasizes how the ports "will be encouraged to act as promoters of intermodality", AdSP underlined the exigence to make traffic flows as uniform as possible from/to the hinterland, by remodulating the volume peaks impacting the port in times and spaces. Interoperability is expected to increase up to the experimentation of a real "synchronized logistic date" between ship/goods and port operators. Considering the lack of spaces due to the morphological asset of the site, AdSP foresees as a competitive potential the availability of inland areas (fully described in the following section), far way from the benches, but which operativity is grounded on info-telematic relations and interoperability of digital systems that also works outside strictly-port borders.

National Recovery and Resilience Plan (PNRR) confirm this perspective through the conceptualization (and funding) of Innovation Ecosystems. In the case of Genoa, local University, National Research Council and Italian Institute of Technology and several local companies were funded by the Plan for the constitution of the RAISE (Robotics and AI for Socio-economic Empowerment) Innovation Ecosystem; its aim is to achieve the goal of digital transition in those sectors acknowledged as territorial vocations, in particular port and infrastructures.

The paper investigates the added value of the Genoese RAISE Ecosystem with respect to territorial priorities and in which way it can support the realization of inland areas needed by AdSP. More specifically, in the following section the Genoa port and the complex design of inland areas are described; then, in the third, the paper deepens the relationship between Ecosystem and inland areas, with some concluding remarks.

2 Port of Genoa and Its Logistic Areas

The trend of port activeness is certainly a meaningful sign of the general economic trend of a city. In the case of Genoa, strictly dependent by nature from maritime traffic and crucial for food and raw materials supply, this indicator is particularly representative of the overall dynamics not only in the city, but in the entire region. In fact, we can say with Hoyle et al. (1997) [11], that a port is structured by the interrelation between an oceanic dependence and a continental one (Fig. 2).

Furthermore, we must not forget that the Ligurian ports always represented a door, an open passage in the Apennines which constitutes the natural outlet of the Po Valley towards the sea.

The XII and XIII centuries had seen the three Republics marinare, Genoa, Pisa and Venice, positioning themselves among the economies that dominated the sea and just

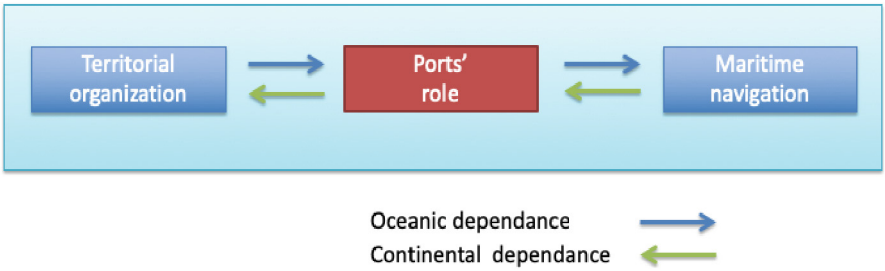

Fig. 2. Relationships between port's role and its territory and sea, according to Hoyle et al. (1997, cit.)

the latter, not being forced like the other two to fight hard to gain a privileged position, it had erected a great protagonist of European trade and beyond. The Ligurian city, after a period in which, despite no longer having a leading role, remains among the richest cities in Europe, rises to prominence again, around the middle of the sixteenth century, thanks to the a certain balance between armament, trade, manufacturing and finance; in fact, that period, thanks to the strategical ability of its merchants and captains, will be defined as the "Century of the Genoeses" [12]. It is possible to consult and access copious documentation about the trend of traffics in the ancient centuries and - with the exception of periods of particular crisis or war - goods have always been increasing up to the present day, although they varied in type and mode of treatment and handling. From the infrastructural viewpoint, in 1874 the city was completely connected by railway lines to France and the rest of Italy: Genoa-Turin, Genoa-Ventimiglia, Genoa-Pisa. Moreover, in the 19th century, Genoa consolidated its role as a major seaport and as important steel and shipbuilding centre, too.

Regarding last century, after a long period of crisis following the economic stagnation of the Seventies and Eighties (due the crisis of heavy industrial plants, especially chemicals), the global increase of maritime traffic (goods and passengers) and the occurrence of urban renewal interventions promoted Genoa, in the the very recent years, as an absolute protagonist of the maritime scene. In 1992 Genoa celebrated the "Colombiadi" or "Genoa Expo '92", the celebration of the 500th anniversary of the discovery of the American Continent by Christopher Columbus. The area of the ancient port of Genoa is restructured and expanded also with the works of the famous architect Renzo Piano. In 2004, the European Union designated Genoa as the European Capital of Culture for that year, because of its historical centre, one of the largest and most-densely populated in Europe: part of it was also inscribed on the World Heritage List (UNESCO) in 2006. The geopolitical positioning of Genoa has increasingly consolidated up to the traffic indicated below (in terms of passengers and goods, Fig. 3). It can be said that, even in a different way compared to the last century in which Genoa was part of the so-called "industrial triangle" with Milan and Turin, it still stands out today as a point of reference for the trade of North-West Italy, of course, but also for in the blue econmy sphere [13].

Starting from the aim to strenghten the Genoa Ports' role, AdSP drew up a Strategic Plan in 2021, in which mjor strategies are contained (Table 1).



A) Goods landings and boardings (tons/year)



B) Cruises passengers landings, transfer and boardings (pax/year)



C) Ferries passengers landings and boardings (pax/year)

Fig. 3. Ports of Genoa traffics, along the years. Source: https://www.portsofgenoa.com/it/chi-siamo/porto-numeri.html

Considering Obj. 2 and the strategic action related to the enhancement of intermodality and actual valorisation of territorial contexts aroung the ports' sites, AdSP proposed a comprehensive project of the whole logistic system, grounded on a shared target: to semplify logistic bureaucratic operations and limitate congestion.

In fact, the second Objective of the Plan focuses on organizing processes and cluster relationships, through the identification of a set of interventions of procedural, technological and organizational innovation. In particular, the development of "infostructures" will allow to rationalize the document exchange while ensuring fluidization of traffic; this will optimize the use of the port spaces and will allow to manage a greater amount of traffic with a relative increase of ground areas. We can also noticed that, specifically, the European Commission puts a special emphasis on promoting unique interoperable interfaces, with the aim of reducing practices administration and the facilitation of traffic. Specific directives on these themes are being implemented such as 2010/65 [14], relating to the formalities of declaration of ships arriving or departing from ports of the Member States and the establishment of the "Single Windows national maritime time".

Table 1. Strategic Plans Objectives and Lines (Source: AdSP)

Objectives	Title	Intervention Lines
1	*Increase in the competitiveness of the port system*	- multi-business vocation of the port system - centrality in the logistics system of the reference hinterland - extension of the reference market beyond national borders
2	*Sustainability of port areas*	- growth of the port system with sensitivity to the environment - reduction of the environmental impacts - enhancement of intermodality
3	*Increase in value for the area*	- strengthening of economic and occupational activities - enhancement of the coexistence between urban and port activities

Particularly, the evolution of the transport and logistics reserch took into account peaks of volumes that occur in conjunction with the ship's dock. The landing of the ship stimulate the infrastructural network systems at a level that has grown considerably in the last few years. This phenomenon is not only linked exclusively to the container sector, but it concerns a large part of the traffic handled within the port system, just think of the case of the passenger sector (ferries and cruises), in which Genoa flourishes. Furthermore, the hinterland production and distribution flows impose rather rigid time windows for loading/unloading operations at the plant/warehouse, helping to make flows from/to the port a variable that is not controllable by the port and its operators. This reflects in traffic peaks, occurring in certain times during the day and during the weekend, which also reverberates in terms of peaks in certain port areas and infrastructures. Additional seasonal peaks contribute to raise the level of operational stress on the facilities of the port.

The Plan identifies therefore, among the prior interventions for the logistics system, the need to soften, as far as possible, traffic peaks, through better distribution of flows both over time (over the day and of the week) both in space (areas, networks).

Better upfront planning and management of the arrival and departure of vehicles (road and rail) to/from and to the hinterland would allow for a more uniform distribution of vehicles throughout the day and along the network, limiting the phenomena of congestion.

In details, promoted actions pertain to:

- "Intermodal appointment": better sharing of information e the introduction of more punctual synchronization elements, new approach in the use of infrastructure and facilities of the port (temporal planning);
- Buffer areas and Simplified Logistics Zones: availability of operational areas outside the port (as in art. 6 National Law 130/2018 [15], Simplified Logistics Zone pursuant to art. 7 of the same Law), which allow the performance of operational activities in these areas, permitting a better distribution, in time and space, of flows from/to the port. In these areas, services for cargo and hauliers will be also included, as functional to both ordinary and in contingency/emergency situations. Furthermore, the flows of vehicles from/to these areas will be organized in order to take advantage of the hours/days off the peak of port operations, relieving congestion port facilities and in general the organization of the port;
- Rest areas and Pre-gates: optimization and flow fluidification also passes through regularization of their trend during the day/week and the organization of a system of passages/gates and related parking areas (internal or immediately outside the port). In particular, regarding rest areas can be identified at least three levels of response that combine with needs different, though often complementary, operations: 1) parking areas/car park 2) areas of pre-gate 3) technical parking areas inside the port. These areas will be digitally equipped to manage remote dialogue and exchange of information.

The network of areas should contribute to raise the level of the service provided, to improve the planning of trips for heavy vehicles and the working conditions of road hauliers, as well as to reduce the level of congestion and externalities of transport. Nevertheless, what has just been reported is sufficient to understand the prominence that innovation and technologies assume at the level of Community policies and how they constitute a new element cornerstone of port planning.

From the research point of view, author prevously focused on the last two types of areas, i.e. rest areas and pre-gates. In fact, following the approach of the AdSP Plan, the features of buffer areas and semplified logistics zones were already determined with a certain level of details (see in Fig. 4: Rivalta Scrivia, Arquata Scrivia, Novi Ligure, Alessandria, Piacenza, Castellazzo, Ovada, Dinazzano, Mi-Smistamento, Melzo, Vado Ligure). While, in the case of the second type, a preliminary areas localisation was already provided but without any indication about how it would be equipped in terms of services.

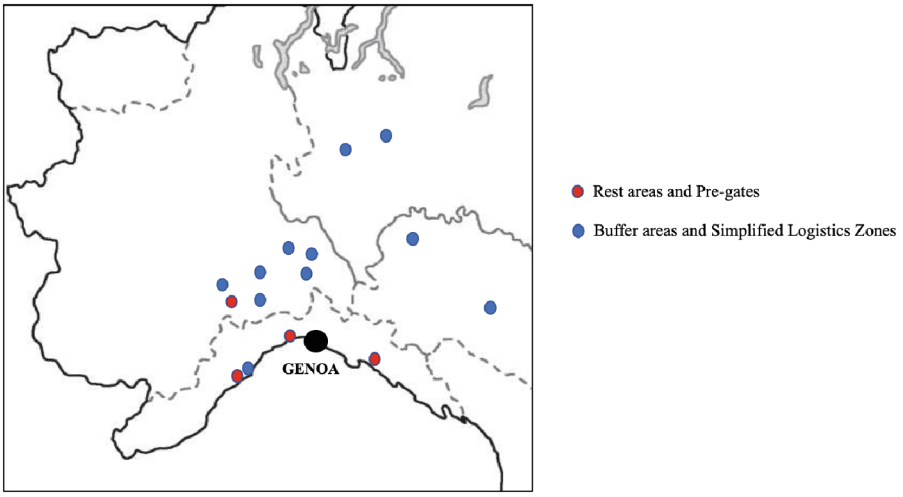

Fig. 4. Inland port areas systems (Elaborated from https://worldmapblank.com/it)

As widely expressed in Delponte et al. (2022) [16], areas devoted to truck drivers services as potential pre-gates of the Genoa port system are:

- two areas are located approximately 30 km from Western part of Genoa Port area along motorway network-Savona, West direction and AdS Stura, North direction;
- two areas are located approximately 30 km from Central part of Genoa Port area along motorway network-Chiavari, East direction and Serravalle Scrivia, North direction;
- one closer area -Ex-Fondega- located between Western and Central Genoa Port Area (distances are approximately 5 km).

The abovementioned paper illustrated the first part of the research (related to the location and provision of services, considering the necessary tools and infrastructures, technical, technological, orographic constraints, etc., and the engagement of the stakeholders and partners) and it can be consulted for further details.

At the end of its preliminary investigation, based on verification of land-use and transport connectivity contraints and key-stakeholders interviews, only two areas resulted properly usable for for pre-gate destination (Fondega and Chiavari) and other two for restoration and services for hauliers' night stop (Savona and Stura).

Nevertheless, despite many project results were already obtained, a wider glance towards such categories of areas in a systematic approach is still lacking. An all-encompassing way to distribute functions and to apply connection and interoperability operations have still to be defined.

At this point of the pursuing of the Strategic Objectives, the RAISE Ecosystem comes to aid for this purpose.

3 Ecosystem of Innovation and Inland Port Areas: Mutual Outcomes and Expected Results

The potential of automation has been talked about for many years now and robotics as a lever to improve performance - of efficiency, efficacy, safety, environmental impact, etc. - in freight transport and distribution logistics is considered as indeniable. The theme is at the intersection of several disciplinary areas of transport and a multiplicity of types of actors are involved.

This is the approach recently promoted by the National Plan of PNRR Recovery and Resilience, but which has very distant roots in time (and in scientific literature): it is the concept of "Ecosystem of innovation". The relationship between knowledge and territory in which it develops has been the subject of numerous studies [17, 18]. The systems premises are constantly evolving (networks, implementation of new supply chains/sectors, local re-composition of businesses e linking them into long value chains) and new technologies are grafted into such an intense and pervasive change.

Therefore, the challenge will be based on the ability of the territories to produce cognitive capital, for which contextual policies will be needed as stimulators of fertile environments for the transposition of new business models. In fact, Ecosystems intervene on areas of technological specialization, consistent with industrial and research vocations of the local territory (regional or supra-regional), promoting and strengthening collaboration between the research system, firms and institutions.

In parallel with the actual challenges promoted by the Strategic Plan of AdSP, Spoke 4 "Smart and Sustainable Ports" has the objective of creating an ecosystem of innovation in support to the several port areas foreseen for the Liguria region. New levels of automation, innovative technologies for collecting data, smarter and optimized processes will be introduced and applied to the big maritime ports (Genova, La Spezia and Savona-Vado) and to the medium/small ones (in the two Rivieras of the region), aiming at reducing the environmental impacts of port activities, improving safety and security, creating a less stressful work environment, defining a new way of experiencing the port within the city. Projects of spoke 4 will be carried out by University of Genova, with affiliates co-founders CNR and IIT, public/research affiliates ENEA and INFN, and industrial affiliates Aitek, algoWatt, Circle, EII, Fincantieri, and Leonardo. These are the main players of this "innovative port ecosystem" and they are currently working together to carry out research and industrial activities, develop technologies, set living labs and demonstration areas, disseminate results to the scientific community, industrial associations, and citizens.

- Spoke 4 "Smart and Sustainable Ports" was built on four strategic lines of research and development (RL) and nineteen research areas (RA). The four strategic lines are:
- RL1. Uncrewed and automated systems for port automation
- RL2. Machine Learning and real-time data for port safety, security, and sustainability
- RL3. Port management in an integrated framework of transport infrastructures
- RL4. AI-powered services for medium and small ports

Considering, in particular, the two lines 2 and 3 -in which the author is involved- RL 3 has the objective of optimizing the performance of the port from many points of view (management, environmental, energy), also exploiting the data collected and analyzed in the second work-package, and even making use of virtual models and digital twins. In this

connection, ports are considered -in a systemic approach- as nodes of a regional network of transport infrastructures. This strategic line includes both approaches devised for ports as "nodes" of the integrated network (as the integration of new and smart solutions inside TOSs, advanced AI and IoT schemes for improving processes, solutions for energy and resource efficiency), and methods and tools for transport networks as "lines" (like advanced monitoring, forecasting and optimization of flows of goods, approaches for reacting to disruptions). In parallel, in RL 2, several data and signals will be collected from various heterogeneous sources (also exploiting the resources introduced in the first work-package) and they will be analyzed for the purpose of traffic monitoring, marine and weather forecast, sustainability evaluation, risk assessment, port protection against hazards and infrastructure maintenance. Robotics and AI technologies developed in this strategic line includes IoT- based solutions to localize, track, and recognize in- and out-bound flows of vehicles and persons; data- driven models for nowcast and forecast of marine conditions including weather, fauna, and pollution; tools to evaluate energy consumptions and emissions, as well as for monitoring acoustic signals for workers' health; intelligent sensor networks for port protection; teams of aerial and ground robots for monitoring and inspection of shipbuilding activities, port areas and goods.

The safety of port workers is a sensible item of paramount importance. Using state-of-the-art AI-inspired technologies the project aims to define a modern framework that will reduce and manage risks in port operations. Starting from a deep assessment of the working conditions and stakeholders' needs, the best strategy minimize risks and define a work plan for continuous monitoring of the port environment will be deployed. A combination of hardware (e.g. remotely operated vehicles, robots, and a network of monitor systems) and software technologies (e.g. platforms for big-data collection and elaboration) will be developed and optimized by public and private partners of the project to increase the current safety operations in the port environment and provide a long-range plan to ensure continuous monitoring and risk minimization in future. To this extent, the goal of strengthening port automation processes through a novel combination of data collection and aggregation from IoT devices, AI/ML and optimization algorithms for (predictive) analytics and automation can be implied, in this case, to improve flows in ports.

From the concrete application point of view, many are the disciplines involved; but, the two research lines have a point in common that is Genoa as the test bed.

The paradigm of the innovation ecosystem, according to its own nature, carries out an idea of the future (innovation) on some selected elements/categories/fields, but it is also a project declined locally, as a sort of evolution of its vocations. In this participatory perspective, the "disruptive" technologies that could be progressively introduced thanks to the research progress, should be appropriately introduced to Stakeholders. This can happen by means of models of acceptance (TAM - Technology Acceptance Models), which verify consensus by the actors and often provide suggestions for the consequent rebalancing of the work activities.

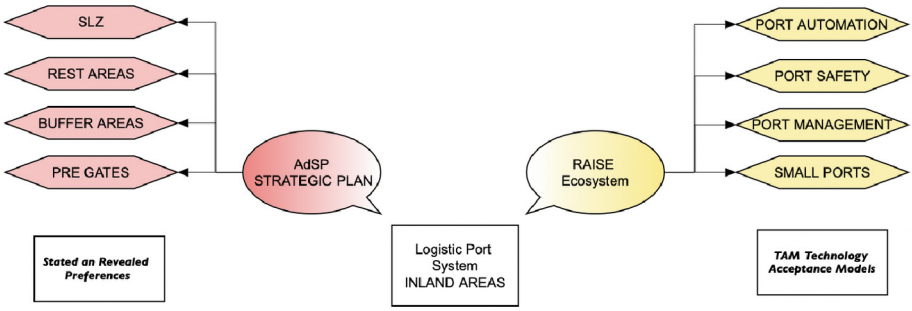

Fig. 5. Inland port areas systems in the Strategic Plan and the RAISE Research Lines.

4 Conclusions

Finally, it seems meaningful to underline that, even if AI and ML are considered "technological" activities, RAISE takes into account the societal empowerment phase equally important, in an all-encompassing way to think about "innovation" in a holistic manner [19]. In fact, one possible objection to the research project could be the will -in some way- to organize the port cluster according to a top-down activity.

However, the shared objective between RAISE and the AdSP Strategic Plan (Fig. 5) is to build a platform -with tested characteristics- able to perform the best in rationalization and optimization of flows, and to precisely define the requirements from a technological point of view. The governance of the process is totally devolved to a sharing process with economic operators; in a possible future, actors will join into a Framework Agreement with detailed procedures and forms. For this reason, likewise important is an active participation of all the parties: port and urban institutions, hauliers, brokers, shippers, carriers, road and motorway managers, etc. Most work will be led not only in the field of AI and ML, but also in other topics/applications such as TAM-Technology Acceptance Models and targeted interviews with stakeholders, which will define the propensities to change and the willingness to pay related to each of the different scenarios. The latter will be accomplished by the Stated Preferences and Revealed Preferences methods (and a connection of the two).

Regarding TAM, we consider it as an information systems theory that models how users come to accept and use a technology; in this, behavioral intention is a key-factor that leads people to use the provided technology [20, 21]. However, when we spoke about Stated and Revealed Preferences as a way to investigate propensity by interviewees, we refer to "stated preferences" (sometimes referred to as contingent valuation) as a survey-based technique for establishing valuations, that is the crucial aim in societal acceptance: in other words, the actor is asked how much they value something. The answer might be based on several elements and it may be very different from the actual behavior. Revealed preferences investigate the actual decisions people make and these may be very different – if not completely opposite from – their stated preferences. Starting from the relationships between the two and the users' profile which comes from them, dissemination and engagement actions can be organize for a better understanding of the project in its complexity.

Considering that the main points of the study concern

- the characterisation of the areas;
- the study of their urban constraints;
- the definition of services in each area
- the feasibility criteria (economic, social and environmental) of intervention in the areas,

it is clear that the acceptance part of the new technologies introduced is an integral and not ancillary part of the proposal considered by the Port Authority and Ecosystem RAISE.

All these components are strategic for an Ecosystem that want to consolidate the local port vocation but also give an added value to its territory, by means of the engagement of its social community.

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