International, National And Regional Sea Transportation Evolution: A Simulation Based Approach To Improve Performances Of Ligurian Ports

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*Abstract***:** The paper presents an analysis of the international and national sea transportation sector with special focus on the Liguria ports (Genoa, Savona and La Spezia). Among other Italian ports these present interesting growing potential but are limited in their growth by lack of space and poor logistics expansion possibilities. The authors have identified a scenario based simulation methodology able to quantitatively evaluate possible strategies and investments effects. In such approach High Level Simulation (i.e. System Dynamics) and hi-Fidelity models (i.e. discrete event simulators) are combined in order to obtain a strategic Decision Support Systems that can be applied in several real industrial application. The paper presents the possible evolution of international, national and regional sea transportation with particular respect to the link existing among sea inland logistics, then is outlining a quantitative model able to describe the complex iteration among the various actors by defining their potentials and identifying the possible bottlenecks. This hi level model, implemented in System Dynamics, can be improved by implementing specific hi fidelity sub models using commercially available packages. The paper finally presents a real life application of the proposed methodology able to accurately model the Alexandria dry ports scenario connected with the three major Genoa port terminals: S.E.C.H., Messina and VTE.

Key words: Dry Port, System Dynamics, Ligurian Ports, Hi-Fidelity Simulation

1. Analysis of the national and international port activity

During the last twenty years, the Port of Genoa, and generally Liguria set up, has significantly changed. The exceptional development of the Far East markets (China and India above all) forced the change of the organization and management structure of the Italy and Liguria ports, particularly Genoa, and not only, which place themselves in an extremely strategic crossroads of traffics traveling on the Mediterranean Sea and the distribution channels towards Europe and America. The Italian and European Port set up is concerned by a continuous grow up in terms of goods and economical fluxes, that from 1980 up today has been affected by an exponential growth; this increase, therefore should not deceive, since from 1997 some critical aspects caused a slowdown of the same compared to the foreseen trends. The risk will be the positive value differential and erosion from 2015. The market globalization as well as the good and container transport/transfer process standardization definitely modified the Italy tangentially micro-port-based activity. Before to analyze the Italian port set up, and in the specific the Genoa and Liguria reality, it is necessary to assess the European and Worldwide container maritime shipping logistic reality.

During the years (Clarkson data since 1996) the containership quota (FCC) on the worldwide total fees, remarkably raised compared to the conventional maritime shipping (General Cargo Fleet), as result, the maritime channel transit fluxes have increased. Each year from the 90s, the average worldwide increasing quote has been around 10% with a development that from the 50M of handled TEU in 1980 touched 400M of TEU transferred in 2005 (Clarkson data). From this first analysis we can understand as the good volume increase had redefined the shipping strategies, by looking for more competitive, economical and rapid transfer models.

From 1990, starting from this set up, more than 450 most important Shipping Companies became oriented towards the fusion, displacing the market towards an

oligopoly reality. As matter of fact today the first 4 worldwide shipping groups hold 39% of the worldwide market of the container transfer; the 4 groups are: Maersk SeaLand, Mediterranean Shipping & Co, CMA-GCM Group, Evergreen Group (Alphaliner data 2-06).

These fusions determined the need to create scale economies through the shipping of container big quantities on a single ship, then by pulling down the average cost/TEU. In fact, if we consider for example a ship loading 1000 TEU by assuming a cost/TEU equal to 100 this cost proportionally decreases to 70 if the ship has a capacity of 6000 TEU (Clarkson). This need has been solved through the construction of bigger and bigger ships; from 1982 in fact the trend to build up great capacity ships has been continuous, each year equal to about 10%, we passed then from ships that at the beginning of the 80s loaded 1000 TEU to the current ships which can carry up to 10.000 TEU (Clarkson data). We foresee that within 2011 there will be about 677 ships, consisting of post Panamax and Malacca Max. The head of a queue of this new trend is China which is the main purchaser with China Shipping. This re-modulation towards the big container capacity shipping will bring for example the goods handled by Panama from the current 280M of tons to 600M of tons foreseen in 2011. The mode and shipped good quantity changing has practically modified or in any case oriented the ship route in the world.

2. Route typologies

Typically the mercantile routes divide into

Type a) "*run the world*" with ships doing the globe circumnavigation through the Suez and Panama Channels. Up today the funnel was just represented by the two channels, particularly by the dimensions of the Panama one which hampered the passage and maneuvering of ships over a well defined tonnage (post Panamax with a capacity between 5000 and 7500 TEU > over than 75.000 tons).

Type b) it is represented by routes defined as "*Pendulum*" which is translated in the connection of the Far East with the Atlantic or Pacific Coast of the United States, by avoiding the Panama Channel, from there the transshipment on other vectors (mainly railways) which carry out the coast to coast trip in about 7 days.

Up today the "Pendulum" model is the more convenient in terms of speed, shipped good quantities and time saving. This kind of model tends to organize the "mother" routes by following a criteria providing on the main route (the "mother") few and big calls defined Hubs where big ships carry out the good transshipment that through smaller ships and minor maritime routes (Feeder ship and lines) will serve the secondary ports (Spoke o/d ports) for the destination/leaving of goods and the territory provisioning. The Hub and Spoke logic and the ship gigantism (post Panamax and Malacca max ships of more than 10.000 TU) centralized the Mediterranean Sea role. In any case we should pay attention to the fact that starting from 2007 and within 2014 it is provided the doubling of the Panama Channel with a further potential and theoretical take away of traffic from the Mediterranean Sea; this would be determined by the fact that the directions and good fluxes would be inverted. Not yet Far East > Suez > Mediterranean Sea > Gibraltar> Atlantic Sea (or Northern Seas) > Panama > Pacific Sea, but Far East > Pacific Sea > Panama (new way) > Atlantic Sea > Northern Seas or Mediterranean Sea. It should not be neglected the recent proposal promoted by Nicaragua to build up a new channel connecting the Atlantic Sea to the Pacific Sea allowing the ship transit with a capacity up to 250.000 tons. The proposal of Nicaragua is undoubtedly audacious if we consider that up today the Panama Channel allows the passage of ships (Panamax) up to 75.000 tons and after the enlargement to ships of 120.000 tons.

In spite of what has been seen, in any case this condition, it does not seem immediately worrying, since the big push from China and India of goods towards Europe should on the contrary, according to provisioning analysis, to grow up.

3. Italian and Mediterranean Sea Port Set up

In the Mediterranean Sea area there has been a container traffic growing, with a continuous average growing from 2000 up today of about 10%; 35 M of TEU shipped in 2005 and a trend foreseen in 2010 of 60M of TEU (Ocean Shipping Consultants source).

Today, in the area included between Suez and the Straits of Gibraltar, the set up is characterized by: 7 Hub ports of transshipment, 3 of them Gioia Tauro, Taranto, and Cagliari located on the Southern Italian territory, 24 spoke ports o/d (with traffics over than 180.000 TEU) 8 of them in the Italian territory (2 in the South: Neaples, Salerno, 3 in the North East: Trieste, Venice, Ravenna, 3 in the North West: Genoa, La Spezia, Livorno). Therefore the mother lines find in the Mediterranean Hubs a door for the Northern Europe market fluxes. The whole of the Italian Ports had in the period between 1993 and 2004, a constant growing of about 64% with a year average of 5,7%, we passed from 2,4M of TEU shipped in 1993 to 9,4M of 2004. The Italian "gate" towards the North is strategically located at the centre of the Mediterranean Sea and, at least theoretically, it is crucial for the provisioning of the states of the Central and Northern Europe. The theory rises from the fact the Italian port

set up suffers an homogeneity lack, system fragmentation, organization and standard lacks, bureaucratic gaps, lack of valid intermodal and infrastructural interfaces. The competitiveness of the "Italian Way" towards the Northern Europe will lost its effectiveness and as a paradox will lead to the preference for the "Gibraltar Way" towards the North (even if this implies the FCC trip extension of about two days) in case of organization distortions causing time dispersions which originally was at the advantage of it.

4. Liguria Port Set Up

The Liguria ports handled containers for a total of about 2,87M of TEU in 2005; Genoa, which treated 1,6M of TEU in 2005, assumes to manage 6M of TEU within 2015.

Genoa is capturing further traffics above all towards the terminal of Voltri (Vte) (managed in concession by PSA Singapore). Thanks to Maersk Line which will implement the working of 270.000 TEU from January 2007, while 80.000 TEU will be transferred from La Spezia and worked at Vte. Always in 2007 Hapag-Lioyd will inaugurate at the Voltri terminal the service of 120.000 TEU towards Canada and USA through the purchasing of CP Ship by transferring the working from the Sech Terminal of Calata Sanita at Vte. Genoa prepares itself to close the 2006 with a traffic increase of 13% and these data can be undoubtedly considered prospectively optimistic. Today Genoa does not dispose of areas consecrated to the distripark functions, if we exclude small areas (about 500.000mq) at the Voltri (Vte) terminal and a small area of Ronco Scrivia. The proposal to develop the inland terminal in the Alessandria area would compensate this lack.

La Spezia in 2005 handled 1M TEU (dati OSC) and disposes of a logistic area with distriport function at Santo Stefano Magra which develops on an area of about 600.000 mq 150.000 of which it is expected that will be covered.

The Port of Savona increased of 75% compared to 2003 (from 53.000 TEU of 2003 to 220.000 of 2005 (OSC Data)) the container movement, it is moreover working for the widening and the dredging of some existing mooring and for the construction of new docks considering the characteristic of the new ships carrying out the shipping (FCC ULCS > Ultra Large Container Ship) having a draught fluctuating between 15 and 25 meters (it is a recent news the conflict for the government authorizations to the port dredging: cancellation of the art. 13 Law Decree n° 262/2006), need to dispose of dock cranes having a capacity greater than 18-18 rows of containers required today and up to 22 rows. The Port of Savona, in agreement with the Local Public Administrations, is defining programs to develop a logistic back-port area located in Val Bornida (Quiliano, Cengio, Cairo, Rocchetta), an area of about 90.000mq.

5. Logistics (railway vector)

5.1 Savona

The logistics of Savona moves from San Giuseppe (through Altare or Sella) towards Alessandria (the intention of Savona is to transfer on railway at leas 35% of the traffic (about 2M tons).

5.2 Genoa

for Genoa through Ovada or Arquata Scrivia towards Alessandria (Novara). Alessandria is, in primis, the natural and more logic area, seen the big available areas (about 16M of available square meters and planned in the district, with the need to have at least 400.00 hectares of stock house surface (about 1/3 of the total)), for the destination, collection and sorting of containers coming particularly from the ports of Savona an Genoa and directed in Europe and to the Northern Sea Ports. The same can be said for Novara that, even if it is not naturally and immediately behind Genoa, has a potential territorial development which can be assigned to distripark of about 2,5M of square meters. The Inland terminal role of Alessandria (Novara), with suitable connections to the Liguria ports, would made the ligurian-piedmontes area a strongly competitive reality, approaching big territorial and logistically equipped areas to the maritime channels. Genoa displaces on railways 25% of the TEU traffic and 75% on the road (remarking and potentially critic datum for the town logistic and road network.

5.3 La Spezia

The Port of La Spezia being not immediately central and connected with the infrastructures towards the North (Corridor 24) is on the contrary strategic for the directions: Livorno and Florence towards the Central and Southern Italy; Bologna towards the Po Valley and the Adriatic Sea area, Piacenza Parma towards Verona and the Central East Europe Markets (Monaco Berlino). Spezia, today, displaces on railways 25% of the good total (243.000TEU).

6. Critical aspects of the Italian Port Development

What we have seen above gives the idea that the three main Liguria ports are different for characteristics (geographic, organization, volumetric of the handled goods, ship type suitable to the entrance

etc.) but for this reason strategic since differently exploitable according to the required characteristics.

These provisional data lead to understand that in spite of the potentials there is the need of a reorganization of the whole port system to be able to compete with this new kind of markets. In the specific case of the Liguria port, particularly Genoa, to be able to organize a Research work which could be effective, it is necessary to analyze some critical aspects in the concerned compartment.

The Port of Genoa above all, and partially Spezia, seen the territory orography, today find some difficulties to further expand in terms of docks, transit areas, deposit or container stocking.

Liguria road network constantly congested (critical viability limit of 2200 vehicles/hours already abundantly overcome) (risk of crash of the town traffic, above all to Voltri and Corniliano, in the case that 2M of managed TEU are exceeded;

Under exploited Railway network (less than 40%) not integrated with the port activities and not competitive (the German DB Stinnes-Schenker is the most important European operator of logistics which is potentially able to manage the port terminal and to lead to a crisis the railway vector Trenitalia Cargo);

Lack of a back-port logistic area (Alessadnria Novara) integrated with the ports;

Lack of suitable and rapid road and railway connections in the path Genoa Alessandria Novara for the connection with the Corridor 24 towards the Northern Europe;

Technology and organization set up without added value and fragmented;

High incidence on the general costs of the Human Resources compared to the worldwide average (Italian average of the working personnel in each compartment); 45 resources/ha at 18euros/h;

Lack of investments as well as of economic and financial resources;

Not precise Standard and lack of an institutional and national level coordinating reference person;

Globalization of the markets putting to hard test the Italian competitiveness.

7. Comparative assessment and development potentials

All the above said lead to understand that the solution does not pass through a single way but it is necessary a wider analysis and the involvement of all the system protagonist actors.

From an objective point of view it seems difficult that the strategic critical points could be solved on the short distance; consider for example that the new markets revolted and overcome proved systems and markets which made the history of the last forty years, an that in less than ten years. The critical aspects mentioned above are only a part of the problems that the Italian ports had to and must face; there are works about these difficulties to solve dated back to 80s.

Now, if in ten years the market that we cannot yet call emerging, since they are absolutely protagonist and draw the worldwide scenario, has revolted the system in terms of costs and technologies, we cannot believe that we can further wait to reorganize the priorities of the Italian ports. The Asian countries, China above all, passed to be land of conquest for the paltry price of the work (the average of two/three dollar per day! With an average yearly income referred to a good employment of 100 euros!) without any know how, with an economic empire calling finance, acquires in all the world, delocalizes it self the production in poorer countries, owns technology and advanced know how (it owns two of the most important ports in the world: Shangai and Hong Kong (the second port of Shangai is under construction. The China is able to produce everything, technology included, with a lower cost of 50-70% compared to the average of the most industrialized countries and the whole with a GDP growing averagely of 10% each year. In the next 30 years it is foreseen that the Chineese economy will be 3 times greater than the USA one (Goldman Sachs data 2005).

India is immediately back to China and aims (speaking about the port field) to develop the terminal of Mumbai through the joint venture participation between Hutchinson Port (Chinese) and the Indian Company Larsen & Toubro; moreover they are working also to the redevelopment of the project for the opening of the second terminal container at Chennai in the southern area of the country. In the port of Jawaharlal Nehru (where work Maersk and P&O) it is provided the construction of the fourth terminal container (in 2004 it handled 2,4M of TEU). The container Indian traffic growth is equal about 15% each year with a great development foreseen in the next five years (FMI data) and a container movement for the 2004 on the 8 greater ports of India, of 3,8M of TEU.

Totally Asia from 2000 to 2006 doubled the container traffic toward the Mediterranean Sea, from 4,2M of TEU in 2000 to 8M provided for the end of 2006. As concerns Italy, the existing works for the development and the relaunching of the port field can in summary be considered as good, but they are missing as a mode believe, of extreme localism, not being oriented towards a network concept which would be the real added value to the system.

8. Creating a Simulation Model for Supporting Strategic Decision Making

Maritime transport is growing faster and faster, and this forces harbours to enlarge their capacity limits and

to optimize time and space management. Nowadays Europe and the Western Country, that in the past exported good to the rest of the world, are becoming an importing area due to the economical and technical growing of country like China. This means that harbours are a sort of first "step" of the Supply Chain that takes raw materials or components from far away suppliers to a national industry [1]. Reduction of system development time, redundancies elimination and flexibility growing are the goals to be reached, and a System Dynamics approach can be the answer.

Harbours must improve their competitiveness, and so to optimize all the logistic operations (loading and unloading, containers handling and storing) in order to minimize the crossing time [4].

They are complex systems and a model representing them has to consider, besides logistics operations, the Information Technology used, the time for customs clearance, the deck management and the presence of a Dry Port. A detailed model of systems like that needs too much time to be built and, once that it has been implemented, its computational time is too long for solving real time problems. But if you look at the system as a flow made by many different factors, then you can model it effectively using System Dynamics [15].

In this context, a System is "a collection of elements that continually interact over time to form a unified whole". All the relationship and connections between its components makes the structure of the system. Dynamics, instead, means that the system is constantly changing, and its variables continuously interact to change the system over time.

System Dynamics is "a methodology used to understand how systems change over time" [22]. The way in which the system's structure varies is called the behavior of the system, so the first can influence the second. System Dynamics helps us to analyze the relationship between a system's structure and its behavior, and so how it answers to any perturbation.

Often the analyzed systems are feedback ones, where feedback is the process in which a change in a variable leads to a decision and then an action that affect itself. A feedback can be positive (it drives growth and change) or negative (it negates changes and stabilizes systems).

In this study we are interested in negative feedback, because we want to keep our system under control.

The development of the logistic scenario simulation model of the Northern Italy represents one of the more important sides of the research activity of the newborn Observatory for Logistics of CIELI.

The model target i sto represent at the flux level the strategic choice effect on the logistics development along a wide period of time. Given the extremely wide nature of the problem to model and the presence of innumerable entities, it is necessary to adopt a simulation paradigm stressing the fluxes. In this way the logistics network will consist of a nodes and arches set described by an opportune; the fluxes, which will establish inside the system will be governed by the metrical parameters of the considered nodes/arches coupling. Then the model shall be used to study What –if type scenarios and assess the possible forecast of the behaviour inside the considered scenario.

9. The Model Architecture

The problem dimension requires a dual step approach: in the fist model we will define the reference architecture through a first simulator development (proof of concept), which is substantially based on the System Dynamics. This model shall represent the good fluxes along the traffic paths raising from the reciprocal attraction of the nodes/arches couples, while the second model (of detail) will develop according to an approach to discrete events whose detail level will be identified during the first development phase.

So as to make integrating the logics of possible model optimization a hybrid simulation tool will be used, able to model both the continuous process (ex. fluxes) and discrete processes (ex. Operating character at terminals). The need to carefully represent the territorial reality will make necessary the simulation tool integration with the geo-referencing tool (GIS) from which the geographic particularization data of the considered logistic network will be extracted as well as the socio-political structure of the different information layers.

The logistics process graphical representation will be an important side of the modeling being, as matter of fact, impossible the same model validation starting from the sole model output data, per for these reasons the simulator will have also in post-processing, a multi-layer graphic interface able to represent in a symbolic way but exhaustive the different logic processes.

At the implementation level, the exploited tools will be STELLA® for the first implementation (general model) and AnyLogic® for the detail simulation. Particularly, the AnyLogic® tool, is the best tool for the detail modeling since it joins the possibility to create hybrid models and interact with models developed in System Dynamics.

The logistic network will be represented by a multi-layer schematization of nodes and arches; each node will be representative of a physical platform (ex. Distribution center) or of logic platform (ex. Traffic coordination centre). To each node will be associated some parameters describing its nature according to the layer each time considered. For example on the road layer the node will be characterized by a receptive capacity, the merchandise layer will be characterized

by the specific process capacity of the different goods, on the economic layer will be the process cost parameters. Each arc will be characterized by a multi-layer metric with which its attitudes and abilities will be evaluated. Each node and each arch will reciprocally exert an attraction factor which will determine on a first instance the flux entity which will be eventually correct by a retroaction of the same flux. In this way a favorite paths from the road and cost point of view will determine a good flux that shall be limited by the same connection saturation level.

At the logic level the physical network will be mapped on a Causal Diagram able to explicit the interrelations existing among the different layer and determine a series of target functions to optimize.

The good fluxes (flux layer) raising from the model after the physical limit satisfaction (physical layer) and in respect of the reciprocal attractions between nodes and arches will be evaluated through suitable cost parameters deriving from the economic layer. Always from the flux layer will be possible to assess the impact on the considered scenario ecosystems through the estimation of a series of ecological indicators (ex. emissions) which if protracted, through the economic evaluation, shall affect the profitability of the same scenario (economic layer).

The model will make possible to assess development scenario of the Northern Italy good scenario, as well as the impact of the strategic choices on the Country System (ex. third pass) both from the profitability point of view and the socio-economical one (ex. settlements, induced activity development). From the first model, in fact, it will be possible to analyze the generated fluxes and the saturation models of the resources/structures; moreover it twill be possible to carry out general analysis if the environmental impacts and of the possible strength/weakness sides.

10 The Implemented Hi-Fidelity Simulation Model of Genoa's Harbour Railway Logistic

Some part of the system needs to be analyzed in an in-depth study, because their optimization occupies an important position in the improvement of the whole system (Nevins et al, 1998). Considering the Genoa port, it can be useful to analyze the railway connection among the three terminal containers (S.E.C.H., Messina and VTE) in Genoa and the "dry port" in Alessandria. As "dry port" we means an area outside the port where the port operators manage all the activities (logistics, transportation, goods distributions and customs clearance) and that has to be considered a port extension.

This study is about a simulation model of the connections between the Genoa port and Alessandria, to analyze the possible critical states caused by the increasing of the flow of goods. The model has to consider also the railway line inside the terminal and the containers handling operations on the dock.

Data are collected about the terminal loading and unloading capacity, the handling time inside the port and the timetable of the railway connections between the two towns, in both directions, in order to find the railway availability for train of containers.

A model has been built with Arena: there are a double entity flow through the system, one going from Genoa to Alessandria and the other in the opposite way. The flow towards Alessandria starts from the block "Arrivals and Port Selections", then it passes trough the terminal using the internal trucks, it is transferred into the national railway line and moved to the "Arrival and Selection" block of the Alessandria location. The flow towards Genoa starts from the Arrival block in Alessandria, it is moved trough the dry port and loaded on the train, then it takes the port railway lines and it reaches the terminal. Entities vary trough the model from ships to containers and trains, according to the considered part of the model.

All the three terminal container of the Genoa port are considered: the model has just one arrival block, but every ship is directed to one of them, and then they are considered separately.

After the model has been validated, it has been used to find the better configuration of the critical point using the Design for Experiment.

At first, the Mean Square Pure Error (fig. 1) has been calculated to find the minimal simulation run that has to be used, which is fixed to 86 days.

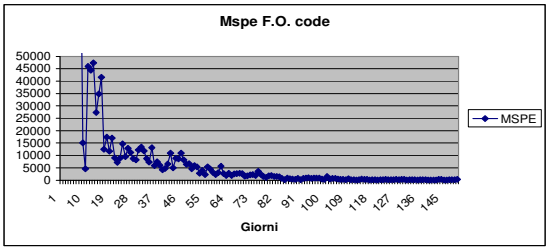

Figure 1: the MSpE trend.

At first, the as-is situation has been simulated to find the bottleneck of the system, which it turned out to be the dry port of Alessandria, so a better configuration of it has been checked. The loading and unloading time in the dry port has been varied from 80 to 20 minutes, while the number of available truck from 2 to 6 (fig. 2).

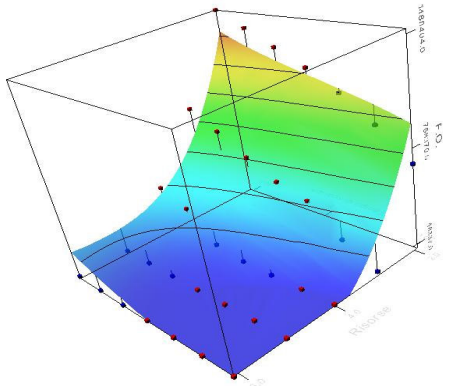

Figure 2: The Response Surface.

As it can be seen in the Response Surface, there is some zone in the domain where the function has a decreasing trend, due to the moving of the bottleneck in some other part of the system that keep the dry port capability from reaching its maximal. The study has evidenced the configuration that has to be implemented in the real system to improve its performance.

Then a second scenario has been simulated: the number of train of container moving to and from Alessandria has been increased to rise the level of saturation of the railway line (fig. 3) and so the capacity of the system.

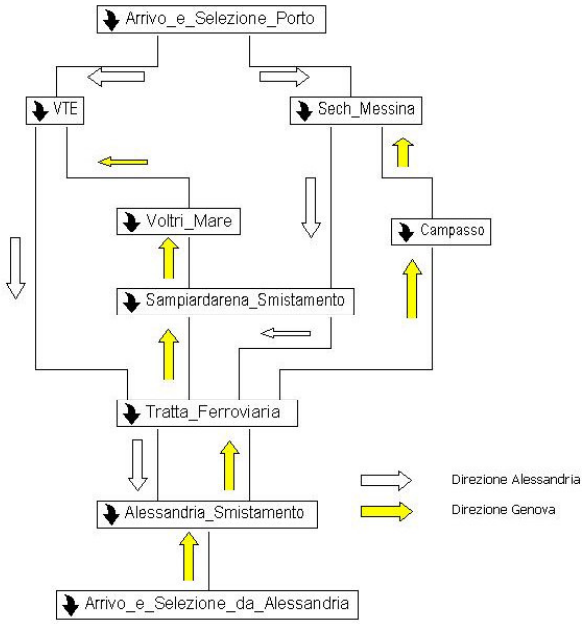

Figure 3: the railway connection between Alessandria and Genoa.

After the simulation study we find the number of routes that optimize the level of saturation without blocking the other parts of the system, finding that the best number of routes .

	S.e.c.h.+Messina	VTE
Number of avaiable trains	28	56
Level of saturation	0,8 (correct)	0,98

Table 1: Level of saturation of the system

12 Conclusions

The development of the market in the modern world leads to a scenario where Europe is more and more an area importing goods from Far East Country. In this situation, harbors and the infrastructure connected to them play a strategic role in the economy of a country. Italian ports, which are lacking in free space around them, are characterized by the necessity of improving their capacity trough dry port situated in different areas, so the connections between them (railway, motorway, highway, exc.) became more and more important. The situation evolves so fast that decisions must be taken before the problem happens, in order to give an effective answer.

In order to support complex strategic decision-making a quantitative model of the entire logistic system should be considered. The paper presented both a real life application of a high-level simulation model and a hi-fidelity simulator able to properly support decision-making in such complex scenarios. Quantitative results have been presented and discussed.

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