The “Net” System Metrocargo®: An Intermodal Solution For The Economic Integration Of The Territory Through The European Corridors Of Transport

---

Nordio, A.
DIMSET- Transportation Section, Faculty of Engineering, University of Genoa

Porta, G.
DIMSET- Transportation Section, Faculty of Engineering, University of Genoa

Servetto, M.
DIMSET- Transportation Section, Faculty of Engineering, University of Genoa

Synopsis

Any new development in logistics and transports must fit with the existing infrastructures, with a broad "international" outlook, meaning "across" nations and European regions.
In other words, the existing European infrastructures should be used and properly integrated with those being planned, with the purpose of integrating and balancing the available transportation modes. The European transport corridors on which the whole multimodal and multifreight logistic process is based must not be seen how a "wound" for the territory, but as an important opportunity to reach the said aim.
Therefore, an efficient system should optimize the overall design and use the best suited technologies to reach the best possible interaction between transport infrastructures and territory.
Our research shows that the “Metrocargo®” model can be an effective way to utilize the existing transport infrastructure and to assure a diffused economic accessibility on the territory.
“Metrocargo®” has been conceived by Eng. Guido Porta and it has been the object of several studies, many of which in cooperation with the Transportation Section of the DIMSET in Genoa. All studies concur to the systemic viability of “Metrocargo®”.
“Metrocargo®” is an innovative system of freight transfer that also represents a new way of conceiving and organizing the intermodal transport of goods. It consists of a network of scheduled cargo trains and a number of terminals, in which cargo units are horizontally transferred from one train to another and/or to trucks for the last leg or to cargo ships. This process determines a remarkable reduction of transport costs and delivery times.
“Metrocargo®” can transfer significant volumes of traffic from the road to the railroad and is compatible with new logistic concepts, such as the “Highways of the Sea” involving cargo ferries.
The application of "Metrocargo®" - a “net” system by definition - on the new European corridors could result in a double function: to act as a catalyst for a more environment-friendly freight transport development, and to increase the economic competitiveness of small enterprises in remote territories.
In conclusion, we mean to evaluate how a diffused transport system like “Metrocargo®” can become a catalyst for an integrated market of full European dimension, giving remarkable benefits to the territories through which the planned transport corridors run.

The “Net” System Metrocargo®: An Intermodal Solution For The Economic Integration Of The Territory Through The European Corridors Of Transport

The European territory is a “complex” system formed by many different realities that must be organized in an integrated net system. The system includes the backbone of the TEN Corridors, collectors branches corresponding to the existing railway infrastructures and capillary branches consisting of local infrastructures that carry resources from and toward the collectors branches. Therefore the European Transport Corridors represent the link between the infrastructures and the territory.

For a geographic area, the connection with an European Corridor means to benefit of an economic and social development created by the free circulation of goods. About territorial development, the Italian Temporary Report - Transport nets connected to the Planning of Structural Funds 2000/2006 - offers precious hints, internationally valid: "it is generally accepted that the mere creation of infrastructures does not automatically entail development, but without a suitable infrastructural system and connected services no development can take place".

Economic and social growth is in fact strictly connected to the availability of transport structures and services, that help making up for to the deficiencies of an area and to increase and to export their own resources. To reach development it is necessary to aim at maximum efficiency and at the best organization of interchange knots. Therefore priority actions on infrastructures must include:

- Innovation of managerial techniques, improving and correctly managing the physical infrastructures to increase efficiency. This may determine both an increase of the transport demand and a diversification of the modal terms, as well as a greater satisfaction of the users for the services offered.
- Considering the nets not only as a connection between knots, but as a way to involve more users and new categories of shippers.
- Connecting both old and new infrastructures with the economic activities that can greater benefit from the use of the infrastructures themselves. This objective can be reached in very articulated ways, such as: construction of new infrastructures according to demand, encouraging integrated transport systems to optimize use of existing infrastructures, revamping both physically and functionally existing infrastructures according to the demand of the economic operators, making traffic more fluent through the use of advanced technologies and the implementation of integrated logistic systems.
- Privileging flexibility of use as a response to uncertainty. In a picture characterized by strong uncertainties it is necessary to privilege “multi-object infrastructures” that can be realized in a flexible way, i.e. multipurpose infrastructures that can sustain different types of traffic and operate effectively and efficiently in different functional phases.

To reach the objective of an economically feasible territorial development, it is necessary to outline a composite transport net merging sea, rail, air, and road transport, with these goals:

- to reach a proper balance between transportation modes, privileging sea and rail;
- to create an integrated system of transport modes in a feeder logic;
- to facilitate the integration of developing countries, keeping into account the great opportunities deriving from the increase of traffic in the Mediterranean;
- to develop logistics services, even if not strictly connected to infrastructures, facilitating the growth of production and distribution processes, to form an overall net system in terms of physical displacement of goods and of communication;
- to minimize new infrastructural investments, through optimum use of the existing and planned facilities and priority intervention on closing of links;
- to respect environment.

In other terms, through a correct use of congruent and integrated European Corridors, and adopting new intermodal technologies related with the demands of the territory, the use all existing and planned infrastructures can be optimized to obtain a better balance and integration of transport modes.

FREIGHT TRANSPORT MODES BALANCE AND EUROPEAN TRANSPORT CORRIDORS

Intermodality is a necessary strategy for an integrated and sustainable development of mobility and territory in an European view. The objective of intermodal balance is among the priorities pointed out by the White Paper "The European policies of the transports up to 2010: the moment of choices" and connected documents.

The European Commission indicated the railroad to be the corner stone of freight traffic. But how is it possible to exploit railways to improve territorial connection at European level?

Part of the problem is that most existing European railways were planned in a period when States were only thinking of local and national transport. Consequently the Union has a many different railway systems that are not integrated or interoperable. Besides the existing infrastructures are not able to face the current unbalance between transport modes, and internal and external costs are too high.

The only solution is to move toward a new modal balance, encouraging initiatives tending to integration. Measures towards this objective are been announced in January 2002 in an package called "Toward an integrated European railway space", that included five proposals aimed to:

- increase net interoperability, i.e. the possibility for a train to run on any railway in the Union;
- establish an European railway agency as a directive body;
- develop a common approach to railway safety;
- complete the internal market of railway freight transport services;
- favour the adhesion of the Community to OTIF, the Intergovernmental Organization for International Railroad Transports, to influence the decisional process and therefore harmonize the operational conditions between Europe and Asia.

The objective of the second railway package of the European Commission was that to achieve a greater interoperability , splitting the matter in two: high speed railways and conventional railways.

High speed lines have an important impact on Corridors with heavy road and air traffic, and offer increased transport capacity to cargo and regional trains travelling on conventional lines, that are left more available.

The essay of the European Union states that the Community must adopt the necessary measures to assure the interoperability of the nets in terms of technical normalization.

To realize an integrated European railway space it is necessary to tackle problems such as: obstacles to planning, divergences at national and sub-national level regarding line layout and height of platforms, technical differences in the running stock and in the signal systems, different qualification of personnel and different management techniques. Currently, international trains can circulate in members States, but these differences cause delays at borders and produce additional costs. Therefore the European Union sets among its main objectives the elimination of bottlenecks in the railway net and the adoption of priority itineraries, with the purpose to improve accessibility to peripheral regions.

In this European picture, Italian railways plan to realize two important high speed / high capacity passenger and freight lines:

- a longitudinal north-south line from Naples to Milan toward Northern Europe;
- a transversal west-east line (“Transpadana”) from Turin to Venice, connected to the Genoa Port, to the international connection Turin-Lyon to the west and to Venice -Trieste-Ljubljana to the east.

In detail, the west-east railway line is the conjunction link of European Corridor nr. 5 running from Lisbon to Madrid, Barcelona, South of France, Marseille, Lyon, Turin, Milan, Venice, Trieste reaching Ljubljana and Budapest to end up in Kiev.

The Milan-Genoa line, crossing Corridor nr. 5, belongs to the "Corridor of the two seas" and it is essential to connect the Mediterranean ports with the North Sea ports (especially Rotterdam).

Figure 1 shows the European Corridors planned on the Italian territory.

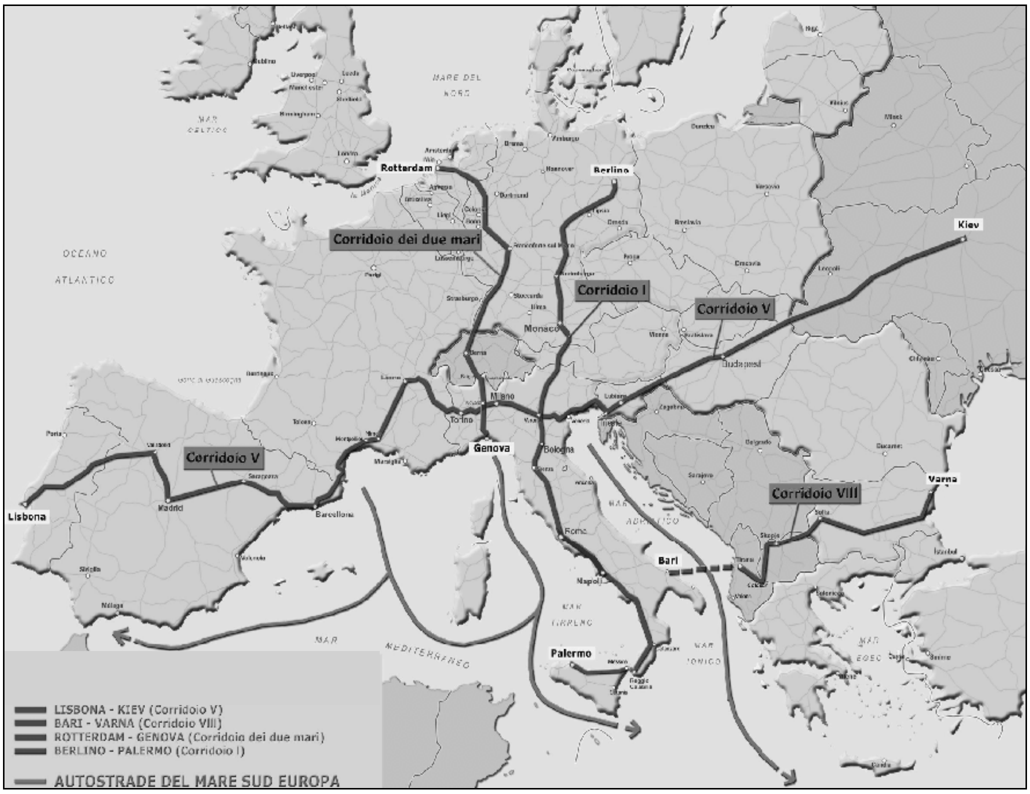

Figure 1: European Corridors planned on the Italian territory (February, 2004).

New railway infrastructures bring advantages both as an increase of the existing national net, and as an integration with the larger European system."

As it regards the first point, the main benefit of “Transpadana” is the strong decrease of travel time: Milan - Trieste drops down to 2 hours 40 minutes from today’s 5 hours, and Trieste - Ljubljana to less than a hour (now over 3 hours).

The second point is connected with the improvement of transit lines for all areas crossed by a Corridor and neighbouring territories; for instance, the industrial area crossed by Transpadana can access eastern Europe through Corridor nr. 5.

The Corridors represent therefore more than a mere infrastructure: they are a big opportunity to be managed in an intermodal way taking into account roads, railroads, waterways and airways, virtual nets and optic fibers for communications, and logistic infrastructures with stocking spaces and other facilities for trade and industry.

But the Corridors, because of the problem listed before, risk however not to be a concrete way to reach a real economic development. Strategies are needed.

THE “NET” SYSTEM METROCARGO®: AN EUROPEAN INTERMODAL STRATEGY

The current unbalance between the different transport modes brings about many economic and social disadvantages: congested road traffic, atmospheric and acoustic pollution, road accidents and high logistic costs.

The situation can be rebalanced and the increasing demand for mobility can be satisfied only through the expansion of the railway systems, the creation of new lines, the improvement of the existing ones and the integration through the European Corridors.

The policy of European integration, and therefore of intermodal development, needs a strong strategy capable of overcoming today’s limits: such strategy can be represented by the net system Metrocargo®, an innovative organizational and technical system supporting intermodal development, patented at international level.

It is necessary to underline that a project financed by the Technological and Scientific Park of the Liguria Region has allowed to create a computer and physical model of a terminal in 1:87 scale.

The project has been supported and validated with (Figure 2):

- Forecasting tools
- Planning algorithms
- Simulators (“Cargo net”) for network and terminals.

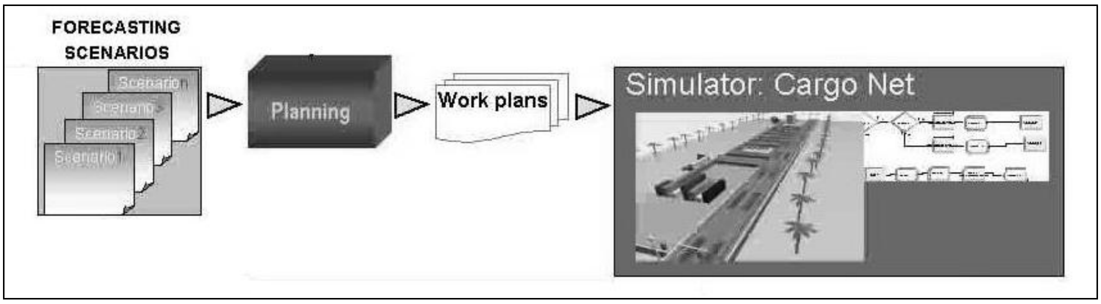

Figure 2: Validation diagram of the Metrocargo® system.

At present, national and European projects are in progress with the aim to complete the technical details of the prototype in 1:1 scale.
Now, it is important shortly describe the philosophy and the technology that are behind the name Metrocargo®, with the purpose to understand how it can benefit the territories crossed by the European Transport Corridors.
In an integrated transport model the itinerary followed by freight is irrelevant, it only matters that it reaches its destination intact, and as rapidly as possible. The managing of such process is called "logistic system", and it guarantees the fluidity of the cycle "procurement-production-distribution".
Mobility of commodities forms a series of logistic flows each of which representing a specialized contribution. Each flow can be divided into legs with specific organizational and technological features.
Obviously weak links penalize the whole intermodal chain and increase delivery time. To make an efficient intermodal system must minimize delays and reduce costs and environmental impact, especially in the transfer between one transport mode and another.
Efficient technologies of loading and unloading cargo from one mode to another make it possible to eliminate or to decrease the diseconomies and to obtain a more effective intermodality.
The traditional terminal is born separated by the railway line, foreseeing a link that involves high costs and delivery times. Besides, nowadays containers and swap bodies are loaded vertically, in a sequential and not in a parallel way, which means that trains have to be moved out of the electrically feed line using diesel traction, loaded and formed and then brought back to the electric railroad. For such reason, the actual average loading and unloading time is around 4 hours, with a remarkable employment of tracks and crane, and critical aspects about the safety and the tracing of cargo units.
Moreover, freight transport by rail is almost totally effected through "block trains" moving from point to point (e.g. from a port to a cargo area), without intermediate stops. This system requires large volumes and steady flows, determining a remarkable rigidity of the service that cannot compete with road transport in terms of flexibility and delivery times. Intermodality must use efficient load transfer technologies to use rail for long distance and trucking for collecting and delivery in limited areas. This way there will be an overall economy and benefits for the community in terms of pollution, traffic fluidity and road accidents.
An efficient intermodal service should be formed by a network of shuttle trains with fixed composition, preset itineraries and schedules, and a number of interchange terminals where unitized freight is transferred from one train to another, as it happens for the passengers in a normal net service.
Metrocargo®, the innovative intermodal transport system, was developed according to this philosophy and, starting from the restrictions of the traditional railway system, it has tried to find technical and organizational solutions.
The system will use scheduled trains on fixed itineraries, with fixed composition, with regular stops placed at 100-200 km intervals in industrial areas and farther apart in areas that are not economically important.
The stations (terminals) are preferably located outside cities, in areas where land is more readily available, next to good roads and motorways. There are knot terminals at the intersections of railroad lines.
The system uses three terminals of different complexity and dimension:

- head terminal;
- basic transit terminal with one loading/unloading track;
- standard transit terminal with two or more loading/unloading tracks.

Traditional stations, ports and interports can also use the system as head terminals, without significant structural changes.
Metrocargo® terminals are based on a technique of horizontal translation that allows to operate under the electric feeding line. Motorized rollers and chains, arranged in synchronized modules, are used for displacing cargo units in the terminal. There are two types of modules:

- modules for two-way translations in one direction;
- modules for two-way translations along two orthogonal axis.

Some roller sets move the cargo to the loading area (area A, Figure 3), others are used as temporary storage (area C, Figure 3); others are used for feeding the loading and unloading units (areas B and D, Figure 3).

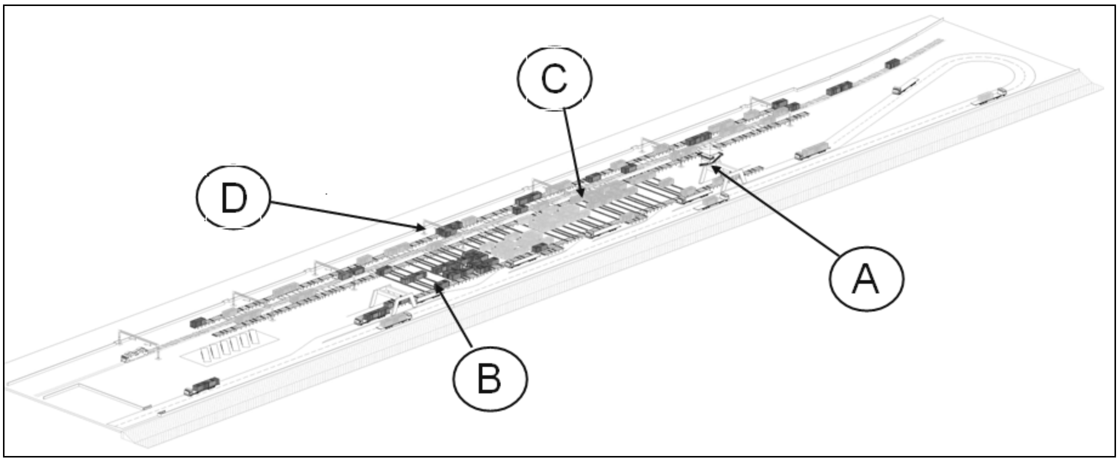

Figure 3: The Metrocargo® terminal.

We specify that the terminals are less than 100 m wide, included the area for the railway line and the access roads, and the operating track is about 700 m long with the possibility to work with trains about 600 m long. Moreover to reduce costs, low volume terminals can be equipped with roller ways covering only part of the train (half train, 300 m, 200 m). In terminal with very low volumes, the storage bays can be replaced by a self moving crane that loads and unloads the trucks, fills the longitudinal loading roller way and empties the unloading roller way. Clearly, in this case the frequency of arrival of the trains has to be at longer intervals, to allow the time for emptying the unloading line and filling the loading line.

The terminal (the prototype is illustrated in Figure 4), has two longitudinal roller ways, one per side: the loading line placed on the side of the storage bays, the unloading line to received the units unloaded from the train. All loading and unloading operations are carried out as the train is standing under the electric feeding line, without removing any wagon from the train.

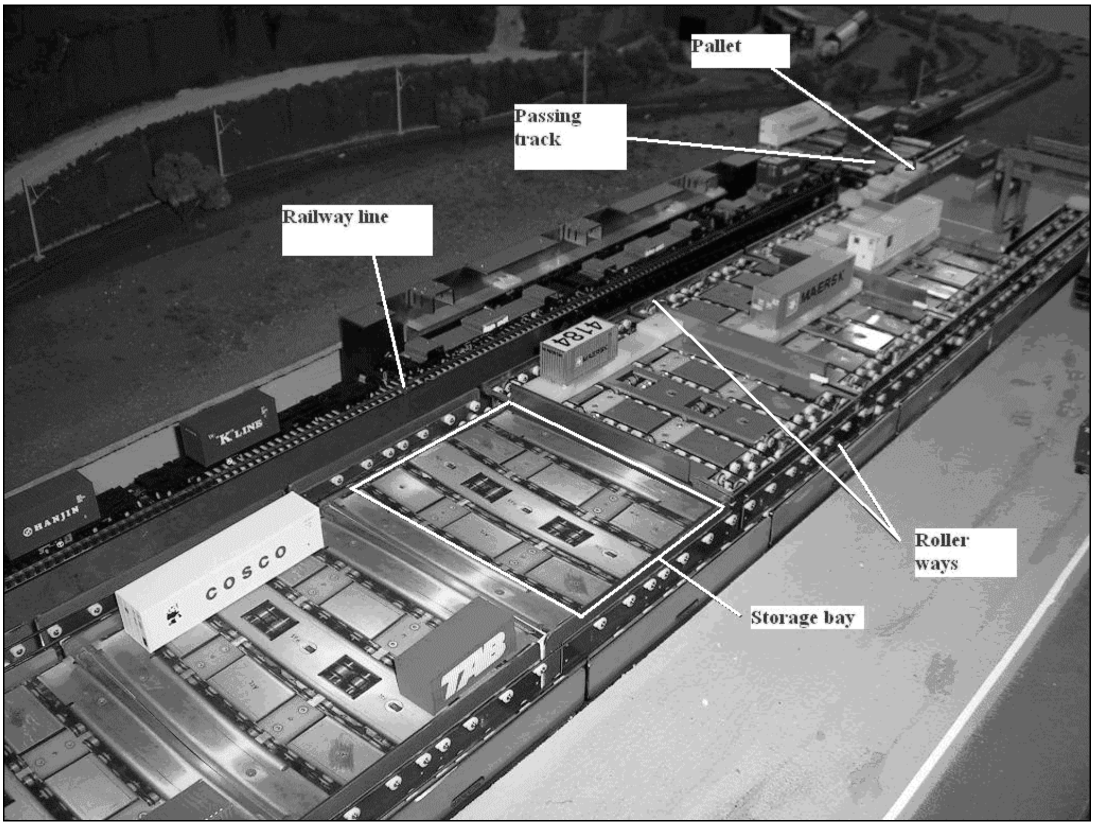

Figure 4: The loading and unloading system (Metrocargo® Prototype – Project of the Scientific and Technologic Park of Liguria Region).

Terminals with two tracks allow to operate contemporarily with two trains, which is especially useful to unload from a train and to reload on another one in a very short time. In this case each track has longitudinal roller ways on both sides and the automated storage area must have a minimum capacity of 80 x 40" load units or 160 x 20", in any mixed form. Each track is equipped with bridging devices.
Roller ways modules are made up of independent sectors, each about 10-11 m long and about 3 m wide, longitudinally positioned to distance of about 2 m one from each other. Each sector is independently powered in sequence to move load units to the desired position. Load units 6 m long interest part of a sector, units 12 m or longer interest a whole sector. Each sector is equipped with two sets of rollers, square to direction of movement and placed on the sides.
Every sector has an independent electric motor, automatically activated by an integrated system of photocells when the load unit approaches, and de-activated as soon as the unity has passed.
In detail, the terminals, laid out parallel to the railway line, have special loading and unloading devices, called “passing track” (Figure 5), that slide the containers or swap bodies on the rail cars, securing them on the twist locks, and that avoid manoeuvres for entry and exit of train in the terminal.
The loading device has a combined system for the longitudinal and transversal movement; both movements are controlled by photocells that guarantee centring the load units with respect to the train wagon.
A passing track measures 3,5 m wide and 15 m long. It is equipped with 4 pitchforks that work in couple 2 to 2: a single couple if containers from 20’ or swap bodies from 7,80 m are moved; both couples if containers from 40’-45’ or swap bodies up to 13,60 m are moved.
As load units have twist-locks sticking out from the base plan, special pallets are interposed to move the units on the roller ways. Therefore there is double flow of load units and empty pallets. It is worth noting that pallets are only used within the terminal and are not loaded on trains.

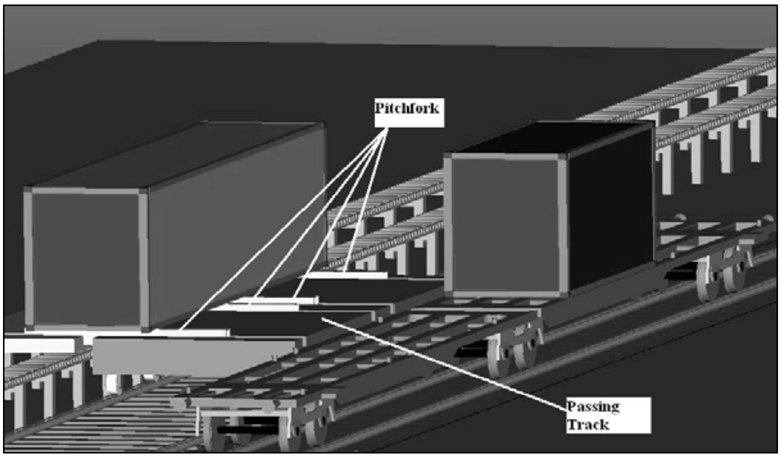

Figure 5: The passing track in Metrocargo® terminal.

Now we can describe the operation of the whole innovative system by a simulation process (Figure 6):

- cargo units that reach the terminal, by track (Figure 6-A) or by rail, are positioned by roller ways in the storage area according to destination (Figure 6-B);

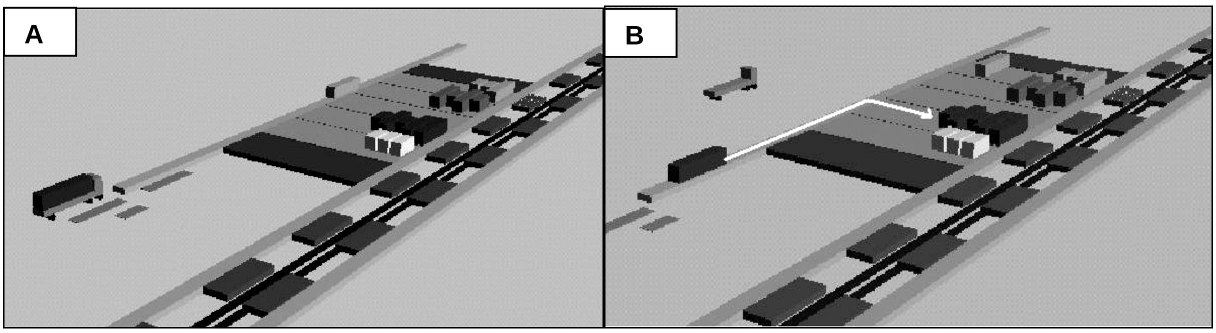

Figure 6: Simulation of the direction of cargo units flow in the terminal: from arrival to storage bay.

- when the train is able to arrive units are pre-addressed and temporarily stocked on the roller way near the railway line (Figure 7);

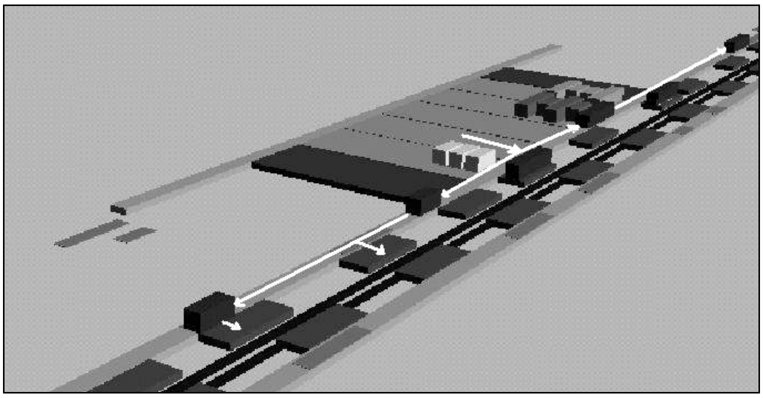

Figure 7: Simulation of the direction of cargo units flow in the terminal: from storage bay to the roller way near the railway line.

- then, when the train is in the station, the units are directly unloaded and loaded on train (Figure 8) using a proprietary loading machine (special pallets are used to move on rollers the cargo units);

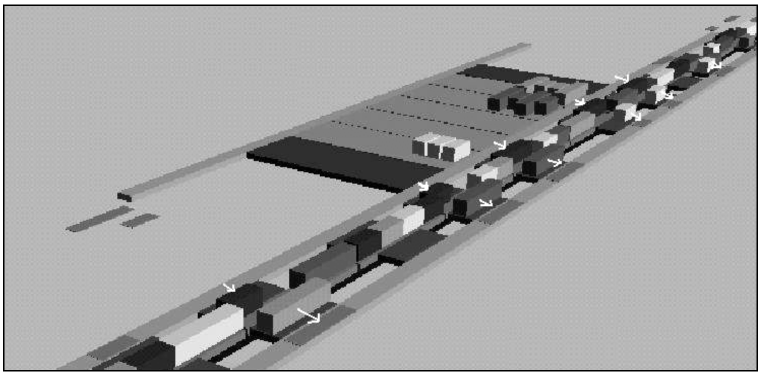

Figure 8: Simulation of the direction of cargo units flow in the terminal: from the roller way to the train and vice versa.

- when the train is gone, the two longitudinal roller ways are connected by a temporary bridging made by the loading devices, to move the unloaded units to the storage bays for further reshipment or to the trucks loading area for local delivery (Figure 9).

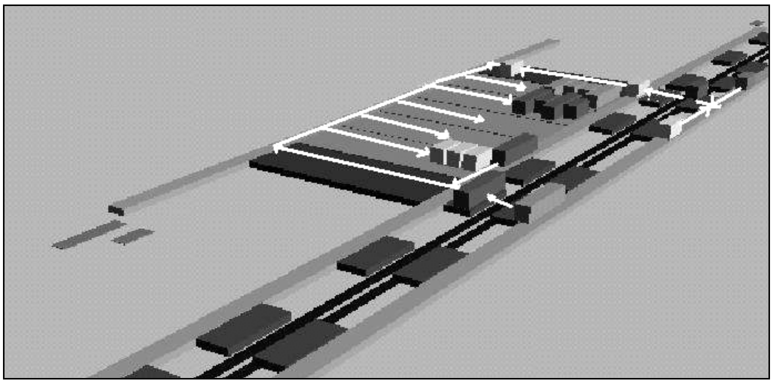

Figure 9: Simulation of the direction of cargo units flow in the terminal: from the roller ways to the storage buy.

We specify that trucks are loaded and unloaded with traditional equipment (Figure 10).

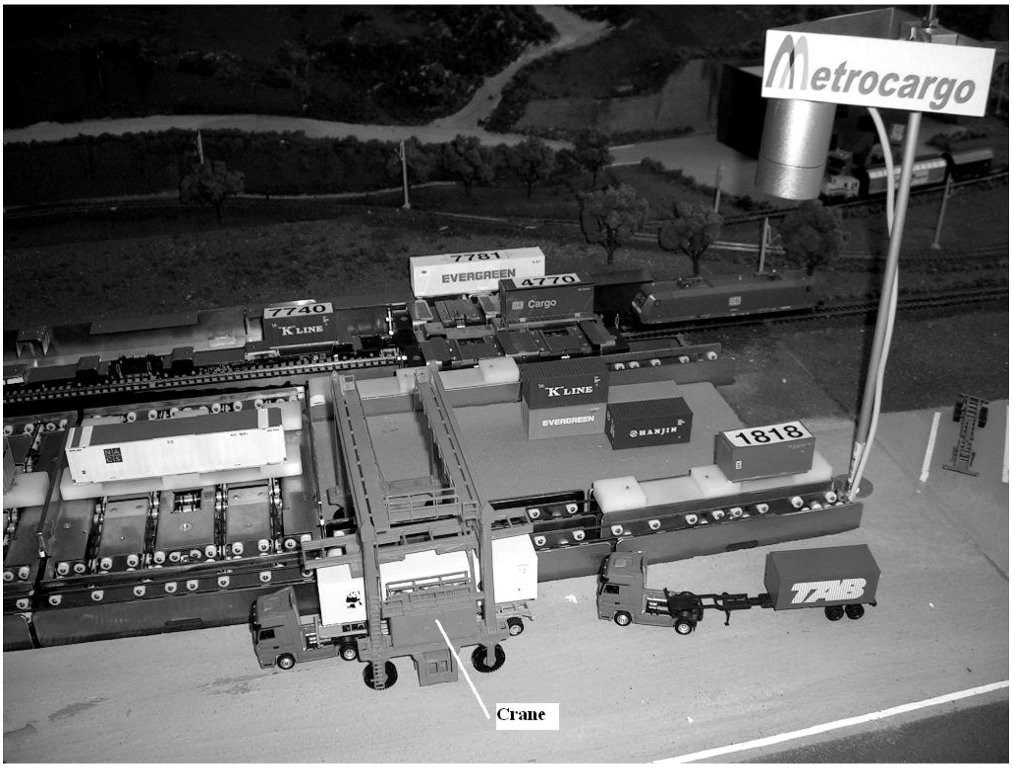

Figure 10: Traditional loading and unloading equipment.

Therefore, towards a traditional system, cargo units don't have waiting for the train that will deliver each one to the final destination, but the units can be loaded on the first available train and then can be subsequently transferred to other trains in Metrocargo® terminal up to the terminal that is near the final destination, where units will be door delivered by trucks.

All done economical and sustainability analysis confirm that the system is feasible. Its main feature is the capability of unloading and loading with unitized cargo a whole train in 20 ÷ 40 minutes, working in parallel with several loading machines, whilst this is usually a serial operation.

Unfortunately, as the project is entrepreneurial type, at the moment it is no possible officially providing exact economic data (costs and revenues) but only the course of data. By this way, in the Figures 11 the temporal courses of the EBIT (Earnings Before Interest and Taxes) and ROE (Return On Equity) indexes show a good profitability of the project.

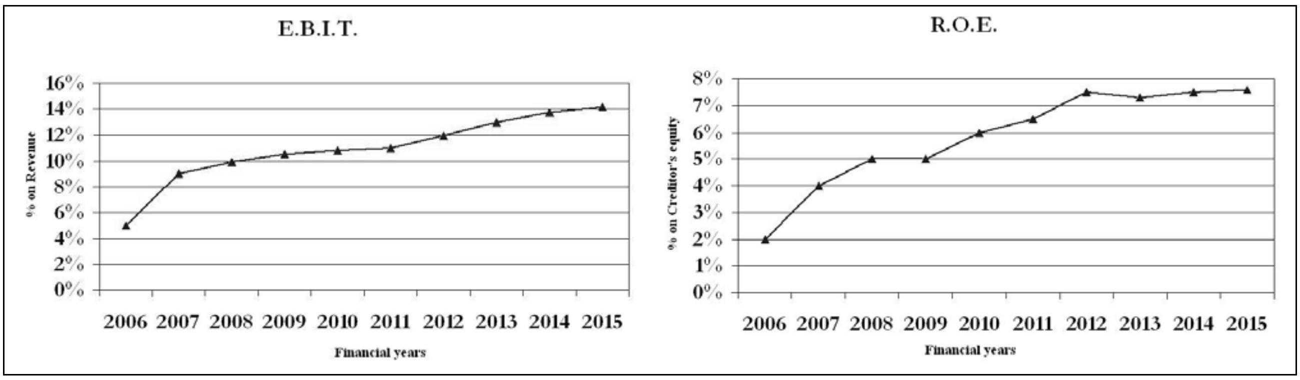

Figure 11: EBIT and ROE indexes of Metrocargo® project.

Moreover, it is no possible even providing the numerical results of the sensitivity analysis. We underline, however, that the "robustness" analyses of the project (a project is defined "robustness" when it is valid also changing the data in a meaningful range) done within the sensitivity analysis on a primary intermodal net individualized in Italy, observable in the Figure 12, and considering progressive scenarios in which the number of terminals and the TEUS flows (modelled considering the actual and future industrial districts) vary, has shown an inferior investment risk to the middle risk in the logistic sector.

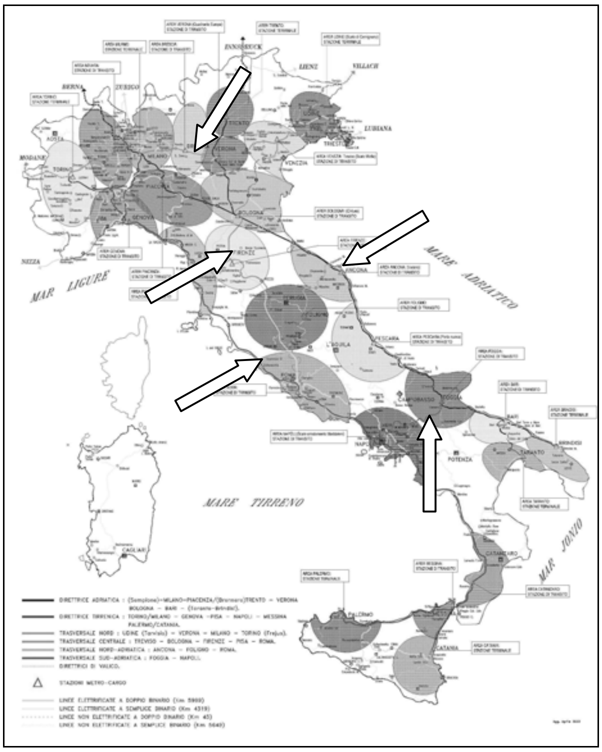

Figure 12: The Italian Metrocargo® primary network.

As the figure shows above, the Italian primary net of Metrocargo® system is formed by: two North / South lines (Tirrenic and Adriatic) and three transversal lines (North, South, Central). This Italian network is composed, in the final stage, by 20-25 terminals, that covers 90% of the national territory, connecting main ports, industrial areas, foreign railways, the existing intermodal centres. Each terminal infrastructure costs 10/12 million euro (as low as 5 million for small terminals); the analyses have shown that a first limited stage of development (5 terminals and 5 traditional stations) can move 150.000 load units with a 30 million euro investment; with 300 million euro investment and 20 terminals the advantages brought to Italy are:
- 1.500.000 less trucks on highways;
- 1.500 / 2.000 new specialized workers;
- 5 - 8% reduction of freight transport cost.

Another interesting analysis shows that, supposing a scenery with 8 lines, 7 input / out terminals, 4 transit terminals (Metrocargo), 20 trains / day, it results:
- an intermodal transport of 700 UTI / day;
- an average handling time in terminal of 30 min;
- a max total transport time of 24 hours;
- an average waiting time in terminals of 8 hours;
- an average utilization space on trains of 70%.

In conclusion, Metrocargo succeeds in getting the results above written because of remarkable technical features:
- it doesn't need strong investments in railway infrastructures (for example, standard rail flat cars can be used with very minor adjustments; the containers and swap bodies used in Metrocargo® terminals have not be modified);
- it is compatible with the existing intermodal systems and the existing or dismissed facilities (railway stations, interports, intermodal facilities, etc.);
- its terminals can be dimensioned according to anticipated traffic, with calibrated investments;
- it allows to serve all the typologies of users, even small occasional shippers;
- it doesn't have preset size limits in terms both of net and of transported volumes;
- it doesn't determine visual environmental impact, given its simple structure;
- it uses electric motors and, therefore without environment impact;
- it can operate both on medium and long distance;
- it operates under the electric traction line, avoiding all problems of vertical loading;
- the terminals can be positioned in dismissed and low value areas adjacent to railway lines;
- it avoids all the costs accessories to the railway transport such as:
  - long times of use of the rolling stock,
  - standstill time in the terminals,

- manoeuvres,
- operations in terminals.

The following step is to understand what advantages this system can bring to the TEN Corridors.

ADVANTAGES DERIVING TO THE TERRITORIES CROSSED BY THE EUROPEAN TRANSPORT CORRIDORS FROM THE USE OF THE METROCARGO® SYSTEM

Till now, the European policies have not succeeded to bring about a diffused economic and social development on the territory. The existing unbalances derive from:
- the lack of suitable infrastructures for freight transport that isolate many local areas;
- diseconomies connected to intermodal transports versus road transport;
- the high internal and external costs of the transport in general.

The existing intermodal nets in the different European countries don't develop the role at which they are destined, because they are formed by a series of “segments” that don't constitute any real linking lines inside the national and European "net" system.
From the viewpoint of territorial development the extensive use of the proposed system would overcome the above mentioned difficulties; its main advantages are to make possible:
- to move significant volumes of cargo traffic from the road to the railroad integrating with other modes of transport both existing and in phase of development, such as Short Sea Shipping;
- to rationalize the current systems of surface transport, using the truck for collecting and delivery and train and ship for the long distance transport;
- to give continuity to the maritime routes directly in the ports, transferring directly from ship to railroad large quantities of cargo units with limited costs and operating times;
- to reduce the environmental impact decreasing road traffic;
- to increase road safety through the reduction of the number of heavy vehicles;
- to reduce the overall cost of logistics determining an improvement of the global efficiency.

The innovative system must be used for giving back a role to the existing infrastructures: the actual terminals (ports and to interports) have to be considered as input points of the net and the innovative terminals have to represent some exchange knots of the net and the collect knots for the competence area. It isn't an infrastructural transformation of the European transport system, but simply it is a reorganization of the same one with the introduction of innovative terminals in key points.
Naturally it is important to locate correctly on the territory the Metrocargo® terminals. To shape a net functional to the economic system, it is necessary to assess transport demand and offer on the territory, concentrating on European industrial districts and large urban centers and assessing existing and planned transport infrastructures. It is thus possible to design a primary net whose centers of development are represented not only by the knots but also by the lines of about 100 ÷ 150 km based on areas of economic significance.
To better understand this, it is necessary to observe the following scheme (Figure 13), related to Turin - Milan - Trieste path, belonging to the European Corridor nr. 5 (direction east-west "Transpadana").

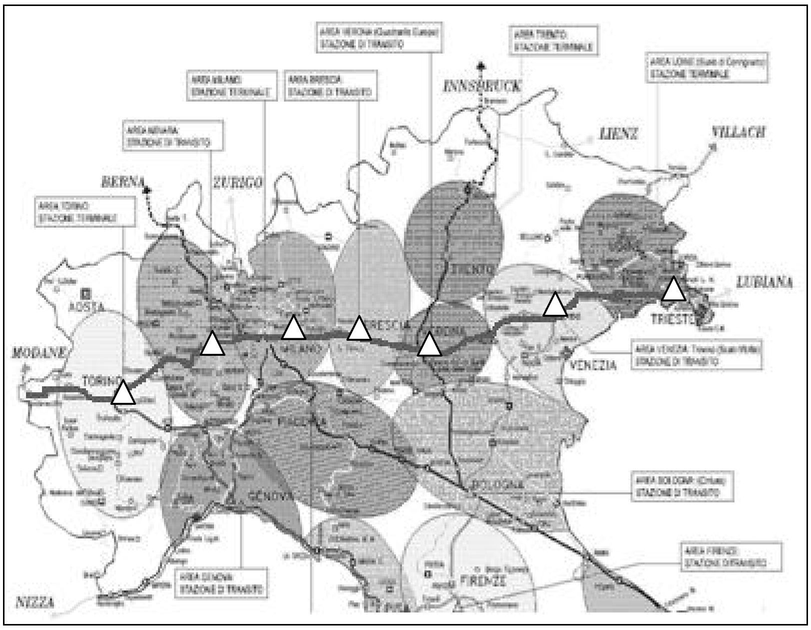

Figure 13: Net terminals on the European Corridor nr. 5.

Along the Turin - Milan - Trieste path, there is a number of economically interesting basins that include areas far away from the Corridor. Positioning a Metrocargo terminal in a strategic point of the net, with capillary branches in the farther economic areas, and connecting it to the Corridor, it will be possible to serve a very large territory. Subsequently, adding more terminals in other strategic points of the Corridor more basins will be served that can be connect determining a actual “economic strip”.
Figure 14 shows Metrocargo branches and terminals diffused on the territory and connected to other Metrocargo terminals located on the Corridor, all together serving the economic strip.

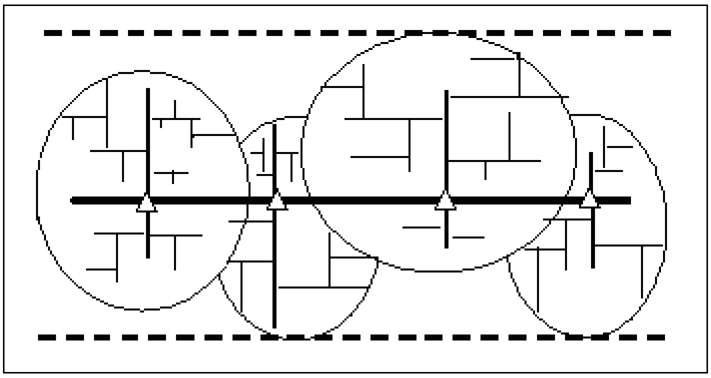

Figure 14: Simplified scheme of an "economic strip" created through the Metrocargo® system.

The Transpadana “economic strip” offers many important advantages, as this system currently:

- guarantees a strategic connection with Europe;
- favors the opening to European markets of northern Italy, enhancing its leading role in the economic, technological and social development of the country;
- favors a more rational usage of existing railway lines;
- contributes to a new modal balance, transferring remarkable quotas of traffic from road to railway;
- considerably reduces the external costs of road congestion, road safety, atmospheric and acoustic pollution, caused by the current modal unbalance;
- consolidates and accelerates urban development through:
    - strengthening the international position of the metropolitan areas and reducing the transit times,
    - the increase of mobility between the cities, increasing choice of working and housing opportunities,
    - the relocation of the productive and activities,
    - the qualification of job markets,
    - the exploitation of the real estate patrimony,
    - the multiplication of the opportunities of collaboration between institutions, firms, people,
    - the creation of skilled workplaces both direct (construction and management of infrastructures, etc.) and indirect, through increased efficiency and competitiveness of the economic strip.

In conclusion, the described advantages are made possible through organization and technologies creating an easy economic connection between different territorial realities.
We now want to assess how the proposed intermodal system can act as a catalyst for a sustainable development. The objective is to use the European Corridors to move away from roads as much traffic as possible, with all relevant advantages.

COMPARISON BETWEEN EXTERNAL COSTS AND BENEFITS FOR A TERRITORIAL ECONOMIC DEVELOPMENT

Overall industrial costs of setting up and running the Metrocargo system are competitive both with rail and road transport, but this is beyond the purpose of this essay.
To validate our previous statements regarding benefits to territorial development, we will investigate external costs of three competing systems: road, traditional intermodal transport and Metrocargo system.
The concept of external costs has been taking a growing importance in determining transport policies. External costs are those not directly paid by who produces or uses the resources or causes damages but those will be borne by the whole community.
Main categories of external costs are:
- atmospheric pollution deriving from use of vehicles, from production of electricity and from other processes connected with transport;
- accidents, especially the costs caused to the community by accidents not covered by insurance (missed production, sanitary costs, damages to the properties, etc.);

- noise, that damages to human health, both organic (insomnia, heart deseases, hypertension, etc.) and psychic (stress, etc.); costs are related to health care, lower productivity, and the so-called costs of distress (pain, anxiety, etc.);
- global heating; according to most recent researches, the worth of avoided CO_2 is 37 €/ton;
- delays/congestion; the delay and uneasiness given to users of transport infrastructures and to the community because of the increase of congestion produced by heavy transport;
- infrastructure use; costs of maintenance due to wearing the infrastructure and not covered by tolls.
To appraise the external costs is complicated because of the numerous variables in play. A reputable study conducted in 1999 by "Friends of the Earth" tries to attribute an economic value [euro cent / ton x km] to every specific imputable external cost. According to this study, the economic values applied to road or rail freight transport are observable in the Table 1.

Tab 1: Economic evaluation of the external costs (Source: Friend of the Earth, 1999)

Transp./External C. [euro cent/ton km]	Gas Effect	Atmospheric pollution	Noise	Accidents	Congestion
Road	1,04	7,26	2,09	0,77	1,35
Rail	0,33	0,65	4,16	0,05	-

Besides, according to the current prices road maintenance cost is 0,02 euro / truck per kilometer.
This analysis doesn't keep into account of the energetic cost of Metrocargo transfer and loading equipment, that is however absolutely negligible.
These data are used to calculate total external costs on 400 km distance (for example, the distance between Turin and Venice on Corridor nr. 5) for road transport, traditional intermodal transport and the innovative intermodal system.
We consider a regular truck carrying 2 x 20' containers from weighing 30 tons.
The following assumptions are made:
- According to European legislation a transport can be defined "intermodal" when road legs don't exceed 20% of other modes. In our case this represents about 40 km.
- Thanks to a strategic positioning of the innovative intermodal system, road transport can be kept to a minimum. In our case we assume 5% (about 20 km) of transport on road.
Results are shown in table 2.

Tab 2: External costs for a 400 km transport of 30 tons

EXTERNAL COSTS	ROAD ONLY	TRADITIONAL INTERMODAL		INNOVATIVE INTERMODAL	
		road leg [euro]	railroad leg [euro]	road leg [euro]	railroad leg [euro]
Gas Effect	124,8	12,5	35,6	6,2	37,6
Atmospheric pollution	871,2	87,1	70,2	43,6	74,1
Noise	250,8	25,1	449,3	12,5	474,2
Accidents	92,4	9,2	5,4	4,6	5,7
Congestion	162,0	16,2	0,0	8,1	0,0
Road maintenance	8,0	0,8	0,0	0,4	0,0
Total	**1509,2 euro**	**711,4 euro**		**667,1 euro**	

As we can observe, the economic advantage for the intermodality is evident, and better shown in following graph.

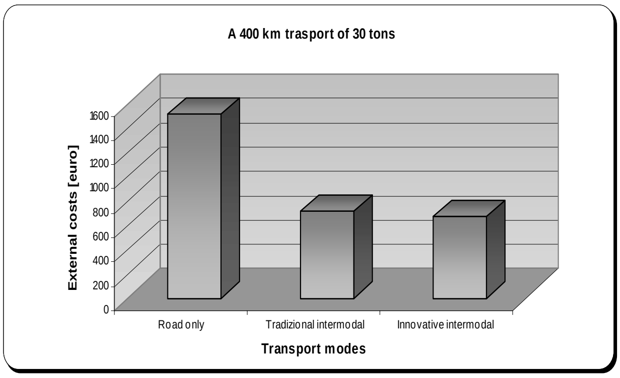

Figure 15: Transport of 30 tons for 400 km: external costs comparison between road transport, traditional and innovative intermodal systems.

The following graphs shows the specific external costs for the three modes of transport:

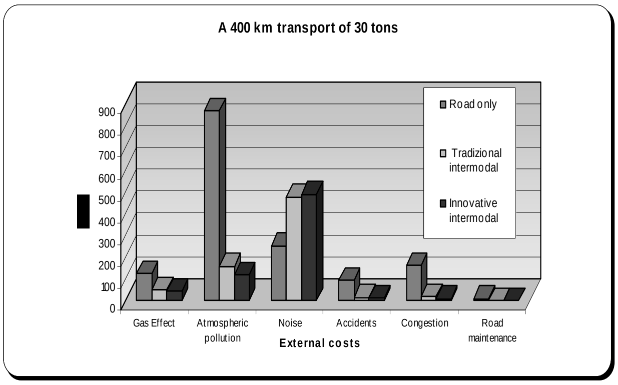

Figure 16: Specific external costs for the three modes of transporting 30 tons 400 km.

An intermodal development means to reduce the number of trucks on the medium and long routes, limiting road transport to collecting and delivery.
We calculate the number of heavy vehicles substituted by the traditional intermodal transport. At present, an average train transports about 56 TEUs. Considering 1 TEU equivalent to 20 tons, a train transports about 1120 tons. Since a truck transports about 30 tons on a medium / long routes, a train is equivalent to 37 trucks. With one more train on the relationship Turin-Venice about 37 trucks transporting 2 x 20’ containers can be eliminated, saving 55.840 euro of external costs versus road transport.
We calculate now the economic benefits of the innovative system in comparison to road transport and traditional intermodal system. Calculations are made for the same Turin-Venice route.

Tab 3: External benefits of the innovative intermodal system in comparison to road transport and traditional intermodal system for a 400 km transport of 30 tons.

EXTERNAL BENEFITS	Innovative system/ road only [euro]	Innovative system/ Tradizional Intermo-dal [euro]
External cost gas effect		
	80,9	4,3
External cost atmospheric pollution		
	753,5	39,7
External cost noise		
	-236,0	-12,4
External cost accidents		
	82,1	4,3
External cost congestion		
	153,9	8,1
External cost renovation road maintenance		
	7,6	0,4
Total Benefits	**842,1 euro**	**44,3 euro**

Graphically:

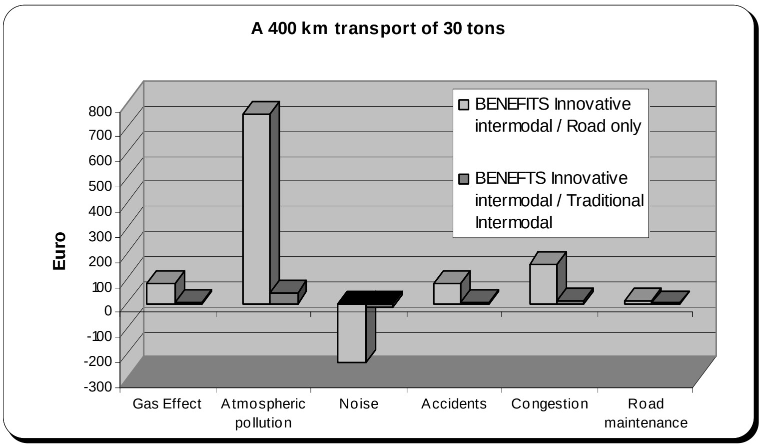

Figure 17: Specific external benefits of the innovative intermodal system in comparison to road transport and to traditional intermodal system for a 400 km transport of 30 tons.

External benefits of the innovative intermodal system in comparison to road transport amount to 842 euro for a 400 km transport of 30 tons, or about 28 euro per ton (0,07 euro per ton x km).
Considering that a freight train carries 1.120 tons (against 30 tons of a truck), replacing road transport with the innovative intermodal system determines an external benefit of: 1120/30 x 842 euro = 31.154 euro.
Now comparing the external costs of the new intermodal system with those of traditional intermodal we have external benefits of about 44 euro over 400 km for the transport of 30 tons.
Such advantage seems limited, however, considering the total load of an intermodal train we obtain 1.639 euro of external benefit in comparison to a traditional intermodal system.
The following graph shows the external benefits of the new intermodal system versus road transport and traditional intermodal transport in relationship with distance.

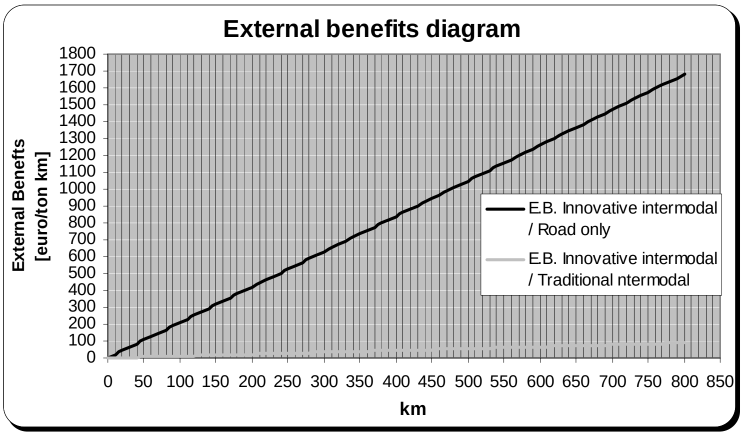

Figure 18: External benefits diagram of the innovative intermodal system versus road transport and traditional intermodal system.

Actually, external benefits of the innovative system, in comparison to the traditional intermodal system, are greater, as the first system requires less fuel consumption due to shorter road travel, even if this cost difference does not show clearly.
Let us now consider delivery time of the two systems.

DELIVERY TIME COMPARISON AND INFLUENCE ON TERRITORIAL ECONOMIC DEVELOPMENT

Reducing delivery time means to make more efficient the whole logistic chain, causing a decrease of the final cost of the products and a reduction of environmental impact.
A study developed in 2002 by the Italian Infrastructures and Transports Ministry analyzed infrastructures, type of nets and loading/unloading time in different Countries, and evaluated the average commercial speed (travel time + waiting times) for road transport, which resulted to be:
- 50 km/h for Italy
- 55 km/h for Germany, Holland, France.

The italian commercial speed data will be taken as a reference in the following analysis on delivery times of surrender of road transport.
It must be considered that road transporters face a drastic change in management of drivers, related to the progressive application of the European legislation on driving and rest time and on maximum driving time in two weeks, and on the pressures not to consider drivers as discontinuous workers, meaning that waiting time should be calculated as work time.
Both aspects have remarkable organizational and economic consequences (cost of the driver accounts for 30 to 40% on the cost of road transport).
Let us now compare delivery time of:
a) road transport;
b) traditional intermodal system;
c) innovative intermodal system.
It should be remembered that, according to Community legislation, in an intermodal transport the road leg must not exceed 20% of total distance.
Comparison is carried out on a 400 kilometers distance.

A) Delivery time (Dt) of road transport
Considering a commercial speed of 50 km/h, overall time including loading and unloading is:
Dt = 0,02 h/km x km = 0,02 x 400 = 8 hours.

B) Delivery times of traditional intermodal system
Overall delivery time includes the followings times:
Travel time (road + railroad + road) + time in the terminal + time of load/unload.
We must make some assumptions, depending on distance and taken from statistics of the sector:
- on a distance of 400 km usually 2 transfers take place (an initial load and an unloading ending);
- average time of loading/unloading = 4 hours;
- average time in the terminal = 2 hours;
- average speed on rail = 50 km/h.

We consider the worst conditions for intermodal transport versus road transport, with the larger improvement margins. Therefore, we consider the same average speed as road transport (50 km/h) even if it could be higher.
With above data we obtain the followings results:
Dt = 0,02 x 400 (travel time) + 2 x 4 (time of transfer = load + unload) + 2 x 2 (time in terminal) = 20 hours.

C) Delivery time of the innovative intermodal system
With the innovative system no time is spent in terminals. Railroad speed is considered to be 50 km/h even though it will actually be higher.
As in case b), to make comparable the two situations, on a distance of 400 km we consider 2 transfers (an initial load and an unloading ending). Maximum loading/unloading time guaranteed by the system, under normal conditions, is 1 hour.
Calculating, we obtain:
Dt= 0,02 x 400 + 2 x 1 (transfer time) = 10 hours.

Comparing delivery time of case b) and c) on a distance of 400 kilometers, the innovative system saves 10 hours. The difference between the innovative system and road transport is just 2 hours, which is negligible considering that the first system is more reliable, not being subject to road congestion, and safer as the risk of accidents is almost nil.

Let us now consider a distance of 800 km.
On a longer run the innovative intermodal system requires to transfer the load units from one train to another. This involves considering in time calculation a waiting time between a train and the other, that, according to realistic assumptions, is 3 hours at the most.
We effect same calculations as previously, considering one transfer.

A) Delivery time of road transport
On a distance of 800 km, according to the law (Rule EEC on driving and rest time n. 3820/85; Directive 2002/15/CE of the European Parliament and Council, of March 11 2002 - GUCE n. L 080 of 23/03/2002), it is necessary to keep in mind the following:
- the truck driver must stop at least every 6 hours of consecutive trip for "at least 30 minutes if the total working time is between six and nine hours, for at least 45 minutes if it exceeds nine hours";
- "if working in the night, working time cannot exceed 10 hours every 24 hours";
- "the daily driving time - that is the time among two periods of rest – should not exceed 9 hours, but, for twice a week maximum, it can be 10 hours";
- "the daily rest in a 24 hour period has to be at least 11 consecutive hours, reduced to 9 hours no more than three times a week."
Calculating:
Travel time + load/unload time = 0,02 h/km x km = 0,02 x 800 = 16 hours
On 16 hours, about 14 are travel time. Maximum legal driving time, however, is 10 hours, in which the driver must stop at least 45 minutes. In conclusion, considering a minimum rest time of 10 hours (value between 9 and 11 foreseen by the law) after driving, we obtain:
Dt = 10 (max legal driving time)+ 0,75 (one stop)+ 10 (rest time) + 6 (remaining driving time to reach the 16 hours of trip) = 26,75 hours.

B) Delivery times of traditional intermodal system
Only one train is used. Therefore, like for the 400 km distance:
Dt = 0,02 x 800 (travel time) + 2 x 4 (transfer time= load + unload) + 4 (time in terminal) = 28 hours.

C) Delivery time of the innovative intermodal system
With transfer between two trains, it is necessary to consider a total of 3 transfers: initial loading + intermediary transfer + final unloading.
Calculating, we obtain:
Dt = 0,02 x 800 + 3 x 1 (transfer time) + 3 (waiting time for second train) = 22 hours.

Comparing delivery time of b) and c) on a distance of 800 km, the new system gives a saving of 6 hours. Such advantage is smaller than in the previous case (400 km), because of the intermediate transfer and the waiting time for the second train. System c) results remarkably faster than the traditional intermodal.
Considering the new system versus the road transport, the transport is 5 hours faster on the 800 km distance that in the 400 km, which shows that the new system is faster system in the long distances.
The following graph compares delivery times of the three systems, considering an average commercial speed of 50 km/h.

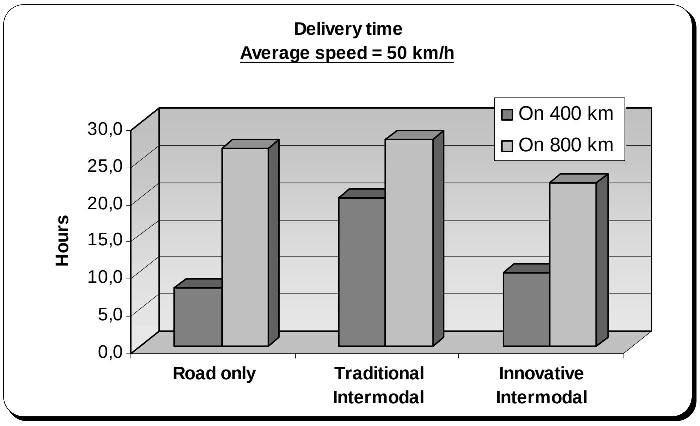

Figure 19: Delivery time comparison between the different transport modes (average speed=50 km/h).

Leaving the restrictive conditions assumed before, let us consider a more realistic speed for the rail leg of the transport. Considering a commercial speed of 60 km/h for train and 50 km/h for road, which is equal to about 5% of the total distance, we obtain:
- on 400 km (380 km by rail and 20 km by road):
Dt = 1/60 x (400-20)+1/50 x 20+2 = 8,7 hours, which is comparable with a road transport of 8 hours;
- on 800 km (760 km by rail and 40 km by road):
Dt = 1/60 x (800-40)+1/50 x 40+3+3 = 19,5 hours, better than road transport which is about 27 hours.

Considering a speed of 65 km/h, we obtain:
- on 400 km (380 km by rail and 20 km by road):
Dt = 1/65 x (400-20)+1/50 x 20+2 = 8,2 hours
- on 800 km (760 km by rail and 40 km by road):
Dt = 1/65 x (800-40)+1/50 x 40+3+3 = 18,5 hours

Graphically, comparison delivery time of the new system with road transport according to distance and speed, we have:

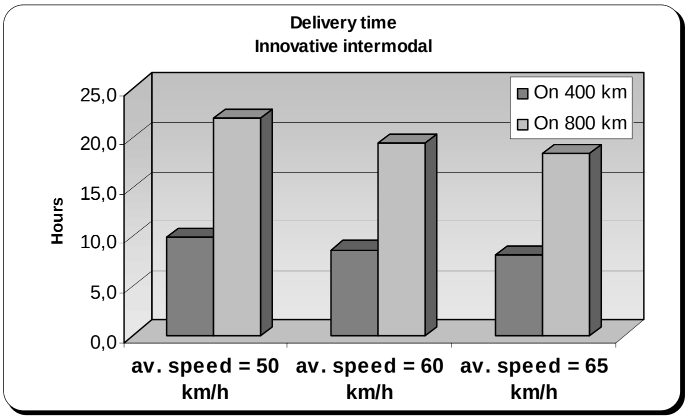

Figure 20: Delivery time of the innovative intermodal system at speed of 50, 60, 65 km/h and distance of 400 km/h and 800 km/h versus road transport.

Calculating delivery time for different values of average speed (maximum 80 km/h) we obtain the results shown in table 4.

Tab 4: Delivery time of the innovative intermodal system according to average speed.

Average speed Innovative system [km/h]	Delivery time [hours]	
	400 km	**800 km**
50	10,0	22,0
51	9,9	21,7
52	9,7	21,4
53	9,6	21,1
54	9,4	20,9
55	9,3	20,6
56	9,2	20,4
57	9,1	20,1
58	9,0	19,9
59	8,8	19,7
60	8,7	19,5
61	8,6	19,3
62	8,5	19,1
63	8,4	18,9
64	8,3	18,7
65	8,2	18,5
66	8,2	18,3
67	8,1	18,1
68	8,0	18,0
69	7,9	17,8
70	7,8	17,7
71	7,8	17,5
72	7,7	17,4
73	7,6	17,2
74	7,5	17,1
75	7,5	16,9
76	7,4	16,8
77	7,3	16,7
78	7,3	16,5
79	7,2	16,4
80	7,2	16,3

Graphically:

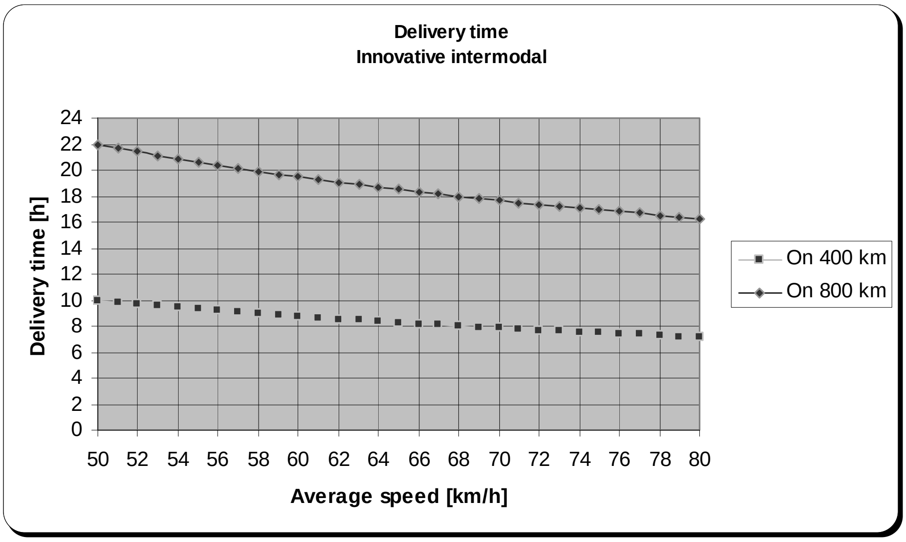

Figure 21: Delivery time diagram of the innovative intermodal system according to average speed.

In conclusion, it has been shown that delivery time of the innovative system is comparable with road transport on medium distances and better on long distances.

One more consideration. The time and cost savings may affect differently the involved actors. For instance, a saving of 3 hours in a road transport between Milan and Sicily, valued about 200 euro, will not be reflected on the cost of transport, as it will only benefit the transporter that will be free before the anticipated schedule. The saving will not be transferred to the shipper as the 3 saved hours do not modify the productivity of the transport cycle (same number of monthly round-trips).

In combined transport, instead, these savings of time result in an increase of the number of door deliveries. The consequent cost reduction is immediately perceived by the transporter, that, to be more competitive, can lower the transport price to the shipper, which, in turn, may reduce the cost of the product. .

CONCLUSIONS

This analysis shows that the “net” system Metrocargo® may indeed determine an economic and social development at diffused territorial level bringing benefits at country level and, subsequently, through the broadening of the "economic bands", at European level.

The Metrocargo® system can represent a support strategy for the development objectives of the multimodal European Corridors, which must be broadly accessible as well as sustainable. This way of using the Corridors determines a modal rebalancing and allows an integrated and sustainable development, for all territories crossed by the Corridors as well as for non-neighboring territories that will benefit of the general advantages brought to the country.

Only a proper balance between accessibility and sustainability can guarantee steady development levels both in quality and quantity.

REFERENCES

DANIELIS, R., ROTARSI L. (2001), *Critical review of the estimate of the external costs of the transports*, University in Trieste and ISTIEE.

DEPARTMENT OF THE PUBLIC JOBS, DEPARTMENT OF THE TRANSPORTS (1999), *Temporary Report - Table about the transport nets Planning structural Funds 2000/2006.*

EUROPEAN COMMISSION (2001), *White Paper "European transport policy for 2010: time to decides"*, COM (2001) 370, Luxembourg.

EUROPEAN COMMISSION (2002), *RECORDIT Project (Real Cost Reduction of Door-to-Door Intermodal Trasport)*, 5° Framework Program of Research.

EUROPEAN COMMISSION (2002), *Relaunching the European railroads. Toward an integrated European railway space*, Luxemburg.

FREIGHT LEADERS CLUB, (2000), *The time value in the road freight transport,* Book nr. 13, Stampa Color Black, Milano.

FRIEDRICH, R., ARI RABL, SPADARO, J. (2001), *Quantifying the Costs of Air Pollution: the ExternE Project of the EC.*

FRIENDS OF THE EARTH, PUBLIC RAILROADS (February 2002), *The environmental and social costs of the mobility in Italy*, Fourth Report.

LOMBARD, P.L., MOLOCCHI, A. (2005), *The environmental and social costs of the mobility in Italy,* 5° Ed, Franco Angeli, Milano.
TECHNOLOGICAL AND SCIENTIFIC PARK OF THE LIGURIA REGION (2005), *Feasibility study of a prototype of "Innovative system of intermodal transport"*, Genoa.