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## Serie Research Memoranda

### TOWARDS AN EVALUATION FRAMEWORK FOR INTEGRATED EUROPEAN TRANSPORT NETWORK OPERATIONS

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## 1. New Challenges in Transport: New Governance and Multiple Actors

Transport is a **derived** demand, which serves to bridge the distance between origins (e.g., places of production, household residences) and destinations (e.g., markets, places of work). This means that transport is part of a **long logistic chain** on which many actors impact: collection, production, transportation and distribution are closely intertwined phenomena. This holds for commodities, but also for passengers (cf. Bayliss 1992).

In recent years this chain has been influenced by various factors or trends:

- the **internationalisation or globalisation** of our economies
- the tendency for a **reduction of regulatory regimes** on transport markets
- the increasing **privatisation** of transport chains or parts thereof
- the increasing **competition** between different modes on the one hand and the need for **complementarity** between modes on the other.

It goes without saying that the European integration will never come into being, if there is not an **efficiently operating network** connecting all nodes of the European network economy. A network is not just a sum of links and nodes, but an infrastructure configuration which aims to provide services through one or several **operators**. A network is thus a value added configuration taking advantage of an essentially passive infrastructure. The positive impacts of infrastructure do not only derive from the mere creation of physical facilities, but from the services generated by operators. This evidence has sometimes been neglected because of the self-operated private car, but as far as freight road transport is concerned or any other mode the operator is a prerequisite to any value added network. This also means that infrastructure investment cannot create economic potential, but only develop it. Thus, a network employs passive infrastructure whose amount of added value is related to the efficiency of operators.

It is clear that an infrastructure network has a geographic meaning and covers a given surface: no network without territory and no territory without networks. A network is related to a territory and has to be recognized and adopted by a **territorial authority** (which can be local, regional, national or European) whose position will be conditioned by the spatial impact of the network. There is a long standing tradition in economic development theory that growth in economic activity is enhanced by trade and hence by physical access to ever larger markets for products and raw materials. Infrastructure network weaknesses limit the realisation of this development potential and, therefore, territorial authorities should be alert concerning the impact of infrastructure on regional-economic development. So any strategic or political change in a territorial governance has consequences at the level of the infrastructure network. In this respect, Title XII of the Maastricht Treaty is the natural consequence of the single market and heralds the birth of the European Union characterized by Trans-European Networks.

In light of the strategic importance of networks, it is also clear that the evaluation of investment programmes related to a network should not be based on

individual ('piecemeal') projects, but on the **synergy** created by network operators in an interconnected infrastructure. This means that an infrastructure network is a cohesive set of links (edges) between concentrations of population or economic activity centres (the so-called nodes), which serve to provide all services (transportation, communication) that are necessary for an efficient transport of persons, goods or information between nodes. The assessment and the evaluation of a network should therefore not only take account of the way such a network can be designed and developed but also **operated** (see also EC 1994).

Internationalisation, reflected inter alia in global sourcing, has created interwoven networks of international trading and industrial relations, in which firms in several countries produce different goods and service components of the same final product. In the last two decades, the globalisation and intensified competition in world trade has not only emerged from the liberalisation of trade policies in many countries, but also from major advances in communication, transport and storage technologies. The 'extended' firm - or the network firm - including formal and informal links (merging or partnership) is mainly economic oriented and follows prevailing market forces, but falls short in including and considering environmental effects and socio-cultural impacts. Therefore, it is also necessary to introduce sustainable development criteria.

It is also noteworthy that infrastructure activities which create the most significant and durable benefits in terms of both production and consumption provide a degree of reliability and quality that is desired by **paying users**. Users charges should be based on economic prices reflecting both costs of supply and demand considerations (willingness to pay) as well as externalities. This means that new policies on network operations should be based on customer's preferences (and not modal interests), user charges and third party access. This approach is called **unbundling** by the World Bank in its 'World Development Report 1994'. In this context much emphasis is placed on three principles: customer driven, user charges and third party access. Public services are provided through a combination of capital and management. Infrastructure is not only a matter of **investment** (or capital stock), but also a matter of **operation and management**. The weaknesses and deficiencies in the infrastructure sector are inherent in incentives produced by the current institutional and organisational arrangements. Production inefficiency is then consequently built into organisations where outputs and inputs are not carefully measured, monitored and managed. Lack of maintenance is intertwined with political and institutional bias toward new investments. Traditionally, the interest in networks was instigated by supply side motives, but it is increasingly recognised that new competitive behaviour of firms in Europe requires to focus much more directly on those actors who coordinate, manage and operate flows in this network. Consequently, much more attention is needed for demand driven activities in the transport sector. But the way towards real value added networks based on **interoperability, interconnectivity and integrated chains** is still very long and full of obstacles, as it also requires a focus on competitive actors in the transport market.

Infrastructure has unfortunately often been managed by means of a bureau-

**cracy**, not as a **service industry**. This model is characterised by poor accounting for costs, little relationship between revenues and costs or between revenue and service performance, and thus lack of accountability to the ultimate users as the 'customers'. Apart from the poor service quality which has often resulted from this approach, bureaucratic systems of infrastructure provision have given little regard to good management of assets (e.g. maintenance of roads, bridges, pipelines) which has often undermined their performance. Consequently, efficiency inducing market instruments should contribute to a greater extent to the provision of infrastructure. Market instruments are here conceived of as competition and pricing. A commercial orientation (e.g., awareness of costs) and financial discipline are basic preconditions for the use of these market instruments. In many infrastructure activities, the potential for applying competition and pricing has been enhanced by technological change, which has altered the nature of production and the services themselves.

For those infrastructure activities which do not lend themselves to market instruments, other approaches are needed to ensure a satisfactory performance. A corollary of this is that governments must focus on, and perform more effectively, the functions which should remain their responsibility, in particular certain well defined tasks of planning and regulation. The planning and financing of national highways, for example, remains a public responsibility in virtually all countries; on the other hand, many countries have adopted the goal of at least partially privatising national railroads (e.g., by privatising railway operations).

As a result of various new market forces, the role of **public** (or semi-public) actors is declining and the importance of **private** operators is rising. Besides, in a long transport chain, the importance of transport and logistic costs may be rather significant, so that **cost improvement** in the transport sector is a necessary condition for reaping the fruits of an integrated European infrastructure network. This means that there is a need for a fresh look at European transport, in particular since transport chains tend to exhibit complex webs of ramifications and interactions. This is, for instance, reflected in the dual phenomenon of a simultaneous rise in standard packaging units (containers, pallets etc.) and in specialized handling services (e.g., fast delivery services). Hub-and-spokes systems, new types of warehousing, just-in-time deliveries and many other phenomena illustrate the rich variety of modalities and configurations that are possible in modern transport activities. It is increasingly realized that the transport chain is increasingly governed by the wishes of the **customer**, so that ultimately the most important driving force in transport operations is executed by those integrators/actors who fulfil to a maximum degree the customers' wishes (in terms of costs, speed, reliability etc.) (cf. OECD 1992).

Transportation planning is often associated with physical movement, with infrastructure configurations and with regulations. Far less attention is paid to the way the transport market is organized, and how this organization uses and shapes transport modalities. Especially the transaction theory of firms has shed new light on the interesting link between firm behaviour and network development (e.g., hub - and - spokes systems). Even though transport systems exhibit

fragmented networks, various operators (e.g., forwarding agencies, logistics suppliers) - through multi-modal shipping, integral logistics and neo-fordist customized delivery - are able to exploit transport networks for generating added value, not only in a local-regional but also in an international context. Globalisation of markets, new forms of competition, more client orientation, integration of production and warehousing, and transport innovations are shaping new opportunities for creative actors in the transport market reflected in joint ventures, 'filières', vertical integration etc. These new operators may to a large extent be considered as integrating actors in a spatial transport system which can be typified according to:

- the structure of the transport market (free competition, market regulation etc.)
- the type of mode (road, rail, waterways, air etc.)
- the geographical coverage (from local to global)
- the quality of service (including scale and scope) and the tariff system
- the sophistication of transportation technology (e.g., logistic platforms, telematics, information systems)
- the structure of the network (e.g., hierarchy, hub and spokes etc.)
- the territorial and modal policy competence on networks
- the barriers to a full performance of networks (e.g., regulations, conflict of competence etc.)
- the integration with telecommunication (EDI, e.g.).

Thus the transport market is in full motion as a result of new technology, new governance and world-wide mobility drift.

## 2. New Roles in Transport

It should be added that the transport function is increasingly shifting away from a purely physical shipment of goods and persons to a **value added process** through which in each step of the chain new services and economic values are added (for instance, assembly in nodal points, service delivery to train passengers in railway stations). This often implies also a transformation into goods or services of a higher market value. An illustrative example is the modern component assembly industry, where components are produced in low wage or cheap resource countries (primary production) and where the final product is assembled - after many transport activities - as close as possible to the final market (secondary production). It is foreseen that value added logistics will increasingly become a major feature of a modern post-fordist industrial nation. Consequently, in particular **central nodes** of a transport system tend to become places of strategic importance. As a result, the **quality** of the organization of transport as a material and immaterial process chain through links and nodes is becoming the new competitive feature of modes in a transport system.

For many shippers and passengers **travel costs** and **travel time** are the most important decision criteria for the choice of transport modality from any origin A to any origin B. It is important to note that travel costs depend - apart from

distance - mainly on volume as a result of scale advantages in the transport sector. This means that large nodes which attract sufficiently high volumes tend to be more competitive as a result of economies of scale. Besides, travel time depends on distance, speed and frequency. The latter implies once again that flows between large centres are offering more competitive advantages. In conclusion, there is a 'natural' tendency to seek for transport routes and modalities which ensure large volumes, a phenomenon which is clearly illustrated in the hub-and-spokes model.

The above observations clarify also the role of two main actors in the transport market, viz. **carriers or operators** who offer transport capacities and facilities (trucks, vans, cars, trains etc.), and **shippers or integrators** (forwarders) who are responsible for a least cost organization of transport. Clearly, in case of private passenger transport these roles coincide in one and the same actor, viz. the car driver.

The above distinction in roles is once more important in case of multimodality, as in this case there may be a **double competition**, viz. **between different transport modes** on the same routes (or parts thereof) and between different **operators** who have to provide competitive services on this route. As a result, the transport system's operation - especially in an international context - has become a complicated activity in which many actors play a role. From the above observation it is also clear that multi-modal international hubs are becoming major action centres in the global transport and logistic system, in particular if such hubs are able to attract new value added activities (mainly based on logistics, complementary services, assembly and collection/distribution in a component industry). A representation of the force field of transport systems can be found in Figure 1.

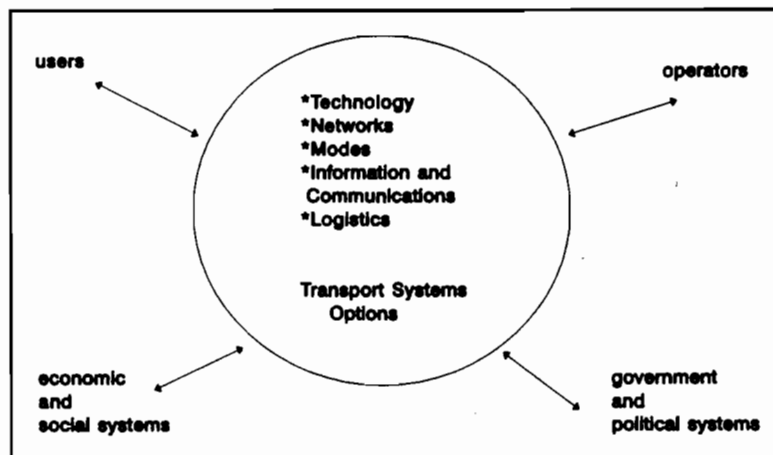


Figure 1. Transport system and its environment  
Source: Pesquera and Ibeas (1990)

Due to institutional, political, economic and technological reasons, the field of European (freight) transport is in rapid motion. A retrospective view at recent developments in Europe gives rise to the following observations:

1. **Intensification** of transport; commodity transport in tonmiles tends to grow



- faster than the economic growth rate in Europe.
2. Increase in **competition** in freight transport; the open character of the European market has generated intense competition leading to falling profit rates in the transport sector.
  3. A dominant competitive role played by the **price-quality ratio**; this means the need for an efficient organization of commodity transport, supported by advanced logistics.
  4. The importance of the **quality of logistic services** (internal and external); there is a development towards a spatial concentration of logistic services which ensures economies of scale and scope (in terms of punctuality, reliability, flexibility, customer orientation, information provision, and packaging of services).
  5. A trend towards '**logistic ports**'; this means that regions which offer favourable opportunities for such logistic services may become dominant actors in the form of logistic mainports (supported by sophisticated telecommunication services).
  6. **Increase in intermodal competition and complementarity**; as a result, the control functions of freight transport will gain importance, especially in transshipment points, so that most likely a new landscape of hierarchically organized and functionally specialized logistic centres will arise.

In this context also the idea of a **mainport** deserves special attention. A mainport aims to fulfil many transport functions, although traditionally the emphasis has mainly been laid on physical movement. In the past decade it has increasingly been recognized that purely physical transport is not an extremely beneficial activity, but generates sometimes even a marginal economic profitability. Several mainports have in the mean time tried to attract additional activities as a spinoff of their mainport function, e.g. services and logistics centres, consultancy companies, and assembly firms. This seems to be the only way of coping with the negative environmental externalities which are necessarily connected with massive transport flows. By generating a higher value added in the same area, more resources will become available in order to finance environmental investments. Consequently, traditional mainports which do not adopt a new environmentally friendly strategy tend to become modern 'pollution havens'. Concentration of transport activities in one mainport should thus necessarily be accompanied by value added logistics and/or services and by intensive pollution abatement (or prevention) investments.

Furthermore, a multimodal and multifunctional mainport has also many more possibilities for **rapid transshipment**. For instance, a deep sea harbour like Rotterdam has an enormous unused potential in terms of connecting short sea links. Such a more environment-benign strategy for waterway transport is of course a major advantage of an international mainport.

### 3. The European Scene

Transportation fulfils a key role in modern societies, not only for road users,

but also to many other actors: public authorities, network operators, industry and society at large. In the same vein, transport is assuming a central role in the new European force field. The context and nature of European trade and transport is entering a new era. In recent years, Europe offers a scene with dramatic changes: integration of the EC market, desintegration of various nation states, and more openness between all countries and regions in Europe. To maximize the competitiveness of such a network, and thus to maximize its socio-economic potential and performance, the quality of its infrastructure is of critical importance, in particular since transport has become an integral part of modern production processes, amongst others due to an intensified division of tasks between firms (in different countries) and a logistic integration of business processes. At the same time, large metropolitan areas appear to become poles of competition in an international context, so that also the quality of a metropolitan network plays a pivotal role.

Furthermore, the structure of production, distribution and transport goes through a rapid transition phase. Integrated logistics inside firms is increasingly linked to external distributional and market logistics, a tendency which leads inter alia to **logistic platforms** in an international network in order to fulfil the needs of just in time (JIT) delivery and material requirements planning (MRP). Multimodal transport will play a critical role in this new development, as is also witnessed in recent policy documents of the European Commission, e.g. in the framework of the EURET programme.

The trend towards globalisation (or at least internationalisation) and the need for more competition at all levels in the new European setting have provoked a profound interest in the functioning of networks in Europe. Traditionally, the interest in networks was instigated by supply side motives, but it is increasingly recognized that new competitive behaviour of firms in Europe requires us to focus much more directly on those actors who coordinate, manage and operate flows in this network. Consequently, much more attention is needed for **demand driven** activities in the transport sector.

Unfortunately, a profound interest in a **European** orientation of users and organizers of transport in cross-border networks has until recently not been very significant, as transport policy and planning were seldom performed at this scale. National frontiers have always provided a clear physical and institutional barrier between countries, even though creative behaviour of network actors has induced growing transport demand in Europe. Intra-European transport infrastructure networks have not followed this rising trend in international mobility and show nowadays various bottlenecks in terms of **missing links** and **missing networks** (see Nijkamp et al., 1993). The emerging Internal Market between the fifteen members of the European Community has put the focus of European politicians and industry (in a more pronounced way) on issues of socio-economic harmonization in order to remove distortions to free competition between industries in its member states, and as a result increasing consideration is now given to transportation and new actors creating a new economic potential. The Maastricht Treaty reinforces the critical function of transportation (infrastructure) for economic cohesion in Europe.

Clearly, economic development and infrastructure development generally, reinforce one another. Therefore, the European economy will remain critically dependent on **well functioning core networks as catalysts for future development**, so that networks become a vehicle for indigenous development. There is nowadays however a growing awareness that the current European infrastructure network is becoming outdated, without being sufficiently upgraded or replaced by modern facilities which would position the European economies at a competitive edge. **Missing networks** emerge because transportation systems are developed in a segmented way, each country seeking for its own solution for each transport mode without keeping an eye on the synergetic effects of a coordinated design and use of advanced infrastructures by various actors. Another reason for missing networks is the focus on hard ware and the neglect of soft ware and organizational aspects as well as financial and ecological implications. Cabotage, protection of national carriers, segmented European railway companies, and lack of multi-modal transport strategies are but a few examples of the existence of low performing European networks. A European orientation towards the needs and behaviour of key actors for the integration of transport modes is necessary to cope with the current problems of missing and competing networks. It seems therefore necessary that nowadays the idea of Trans-European Networks is strongly advocated by the European Commission. But it is equally important that the strategic position of public and private actors (suppliers and users) is better understood and taken care of in network policy. Creative use of multimodal networks may turn competition into complementarity and offer a contribution to sustainable transport.

Consequently, a new element to be considered in the current European transport policy scene is the changing role of actors in this field, in both the public domain (e.g., infrastructure owners or transport authorities) and the private domain (e.g., freight forwarders or logistics suppliers). A major issue is whether and how transport regulatory policy can be used to create conditions for fair competition, based on a creative division of tasks between public authorities and private actors with the aim to generate added value on using intermodal networks in Europe. This issue is once more important in light of changes in decision processes of freight forwarders, new acquisitions and mergers in the freight industry, and company diversification into non-core business.

The notion of **interoperability** of networks, as advocated in the Maastricht Treaty, generates a series of important issues which deserve thorough attention from the side of policy-makers and the research community:

- the operation of transnational networks, seen from the viewpoint of European cohesion and East-European (re)integration
- the close connection between the development of transport networks and (tele)communication networks (including new logistical systems) and their potential implications for the European space (e.g., polarisation tendencies towards larger metropolitan areas)
- the new roles of public and private decision-makers, where a creative division of tasks has to be found between public authorities (urban/regional, national, European) and private actors (transport operators

- and logistics suppliers) in order to generate value added networks
- the interconnectivity of high speed long distance networks and new regional-local infrastructures in central nodes of the European network
  - the role of physical barriers (and organizational impediments) which reduce the benefits of economic integration in Europe (including the connections with Eastern Europe)
  - the emerging conflict between environmental sustainability, infrastructure expansion and competing networks (notably competing transport modes)
  - the impact of new transportation, logistic and (tele)communication technologies on infrastructure life cycles in the European space
  - the lack of standardisation of transport systems technologies in Europe, which hamper the full benefits of an interoperable European network
  - the completely different financing regimes for European transport modes, which prevent a fair competition
  - the lack of strategic insight into the linkage between European networks and global networks developed in other regions outside Europe
  - the behaviour of 'network actors' who aim to fulfil the needs of a global (or European) economy.

Only recently, the awareness is growing that interconnected networks (supported inter alia by modern telecommunications and information technology) may offer a high added value. Despite its potential, **interoperability** between different modes with a view on **cohesion** of European transport systems in order to use the transport capacity as efficient as possible appears to be very difficult to achieve in practice, mainly as a result of a missing solid underpinning methodology. Two factors of strategic importance have to be envisaged in this context:

- **complementarity** between different nodes in order to benefit - in terms of added value networks - from synergy (e.g., rails and waterways, roads and airports etc.)
- **competition** between different nodes in order to operate under the most cost-efficient conditions at a European scale (e.g. common carriage).

It is clear that the goal to maximize value added from the use and operation of a multimodal international network will generally speaking best be reached if the impediments to free access of networks are at a minimum. Only reasons of socio-economic distributive impacts or sustainability requirements may (temporarily) restrict free entry, but economic efficiency through competition is normally best served through actors with a free choice of different modes. This means that integration benefits will be higher as third parties are able to reap the advantages of an interconnected infrastructure network. This once more emphasizes the need to look into the behaviour of key actors as a foundation for international network policy.

In a deregulated transportation network the network performance is customer driven, so that ultimately the user (or customer) value - in terms of benefits or cost-effectiveness for various actors and users - is determining the overall

economic performance of a network. Since transportation in a network is a very complex undertaking which covers a long chain from production - via storage, collection, transport, warehousing and distribution - to final use, the role of integrators in generating value added - in particular, via cost savings on the transport chain or via a spatial reshuffling of certain activities in the chain - is of decisive importance. As mentioned above, there is a variety of integrating activities which are performed by a different players - operators, consolidators, forwarders, shippers or carriers - and which are fulfilling complementary roles in a competitive market.

It is clear that the performance of a network is - apart from demand factors, capacity limits and network design - strongly influenced by various driving forces, in particular:

- **institutional organization and management** of a network (usually called **orgware**); such control functions of a network serve to increase the efficiency of infrastructure services, to enhance the access and equity conditions and to ensure sustainable operation and development in an environmentally conscious society.
- **network configuration** in terms of structure, cohesiveness, synergy, accessibility and flexibility for the operator or customer; a network configuration aims to offer services which are tuned to customer (or user) wishes and which are in agreement with the product specifications of the goods to be shipped or the user wishes of network customers. In this respect it is noteworthy that there is not a single network configuration, but a wide array of ramifications (e.g., multi-hub systems, hierarchical structures, point-to-point connections) which may serve inter-connectivity, inter-operability and intermodality. It goes without saying that especially the volume or critical mass on a certain corridor is of critical importance for the type of network configuration that may emerge.

In light of the previous observations it should thus be noticed that the evaluation of network performance will normally take place within a constrained domain that is shaped by a force field comprising environmental sustainability, institutional decision and managerial structures, spatial interconnectivity at various (local, regional, national or international) levels, and degree of standardisation of various transport technologies. On top of it, new management and control functions of operators (including logistics and informatics) have to be envisaged, such as fleet management, integrated logistic services, telematics opportunities (e.g., tracking and tracing) etc., which will increasingly cover multiple transport modalities. Finally, it should be noted that a focussed fare policy is a sine qua non in order to increase the value added induced by infrastructure investments. Especially in case of competing modes or competing types of vehicles on the same route, contestable markets may increase efficiency - by its orientation towards differences in willingness-to-pay. As a consequence, the quality of a network - and its value added generating capability - does not only depend on the quality and capacity of links connecting transfer points, but also on the quality of transfer and terminal points in a network. Therefore, interoper-

ability (aiming at improving the technical compatibility between networks), interconnectivity (aiming at improving the accessibility at all geographical levels) and intermodality (aiming at improving the customer (or use) value of different modes) are focal points of European infrastructure network policy, as these concepts are crucial handles for enhancing the socio-economic benefits of European networks. A methodological framework of analysis which may offer concrete indications for assessment is however missing thus far.

#### 4. An Evaluation Framework for European Networks

In view of a pro-active European infrastructure policy that aims at maximizing the performance, and thus benefits, of interconnected networks for European countries, it is necessary to develop an appropriate analytical framework for assessment and evaluation, based also on a set of meaningful and practical indicators. It seems reasonable to measure the added value and synergy of a (European) network configuration by means of a benefit criterion which we will indicate here by the general term **(network) performance**. Here we will assume that this performance is determined by (i) **quantitative use** indicators related to actual demand (function, fulfilment or use) in relation to capacity and (ii) **qualitative structure** characteristics which depict the cohesiveness (or synergy) of a network in terms of modes, regions, interconnectivity etc.

We will first focus on **quantitative demand** features. If we take for granted that the final objective of a cohesive European infrastructure network policy is the maximization of its performance  $P$ , e.g. its contribution to GNP (or GEP, Gross European Product), we may assume the following relationship between the **network performance** (e.g., growth in GNP as a result of transport operations) and the use  $D$  of transport services on a network (measured in values or volumes) in the country or in the network concerned (see Figure 2). The slope and shape of this curve is co-determined by managerial abilities, sustainability constraints, capacity limits and network interoperability.

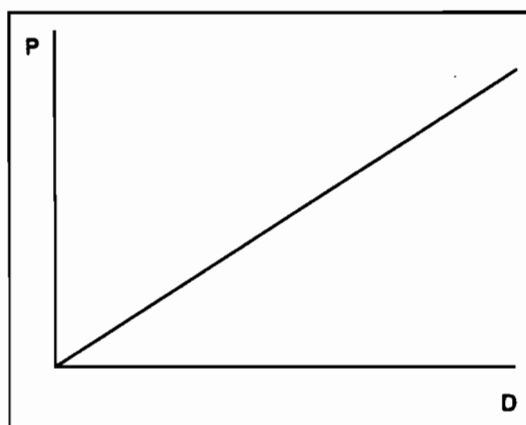


Figure 2. The performance-use curve

It is clear that a high inflow of many users will encounter access and use limitations caused by a limited capacity  $C$  and hence will create congestion phenomena and other external costs (e.g., environmental decay). This may then mean that we have to relate the network performance to the use-capacity ratio  $D/C$ . This is conceptually depicted in Figure 3.

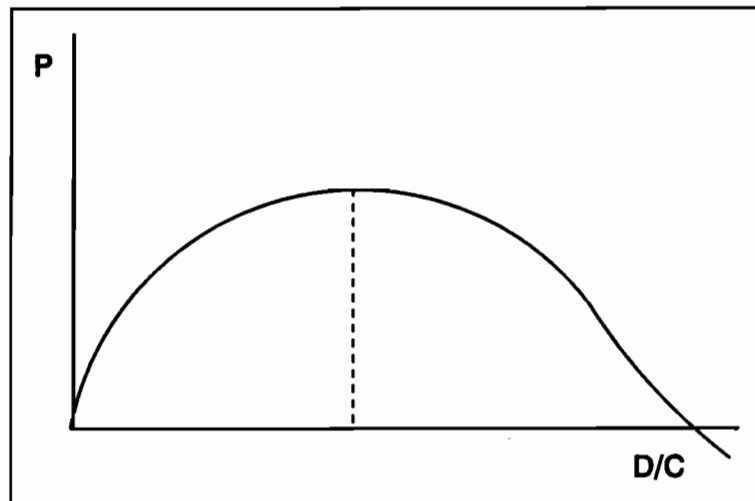


Figure 3. Relationship between demand intensity and network performance

The average  $D/C$  ratio is essentially a measure for demand intensity and its value reflects a potential growth possibility of the network use. It may also be interpreted as some sort of average productivity of a network, if the demand would materialize as actual use. Figure 3 depicts clearly diseconomies of scale beyond a threshold value of  $D/C$ , caused by congestion. Underutilisation of a network creates of course also a low contribution to  $P$ . Clearly, an operationalisation of this curve would require an assessment of relevant empirical indicators.

Next, we will focus on **qualitative structure** features representing different perspectives on the **cohesiveness** of a network. This cohesiveness is made up of different characteristics which - according to the discussion on transport policy that emerged after the Maastricht Treaty - can be summarized under three headings: **intermodality**; **interconnectivity**; and **interoperability**.

The measurement of these concepts is clearly a difficult research task and deserves due attention. It is clear that, *ceteris paribus* the given use of a network, its performance will be higher the higher the scores on these three characteristics. It would be important to construct one aggregate cohesiveness score.

If it were possible to derive a single compound **cohesiveness indicator**  $H$  from these three background factors, we might assume the following relationship between network performance  $P$  and cohesiveness  $H$  (see Figure 4).

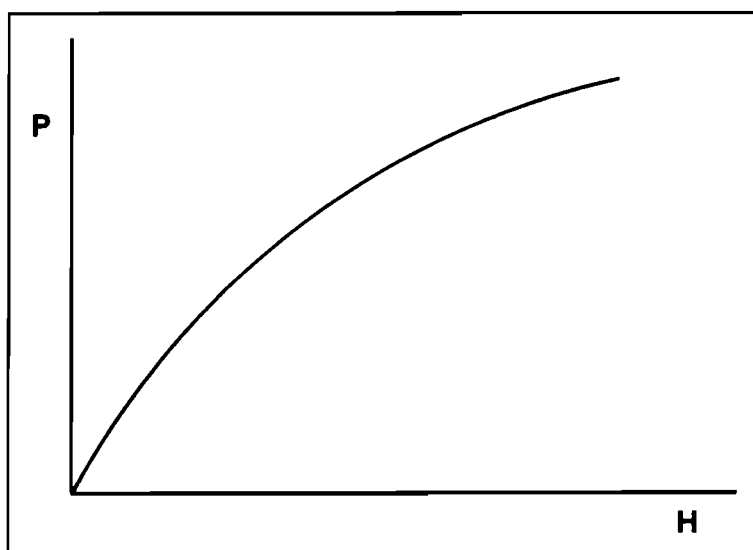


Figure 4. Network performance as a function of cohesiveness

Here we have assumed declining marginal network performance for increasing cohesiveness. Combination of Figure 3 and 4 would yield the following overall result (see Figure 5).

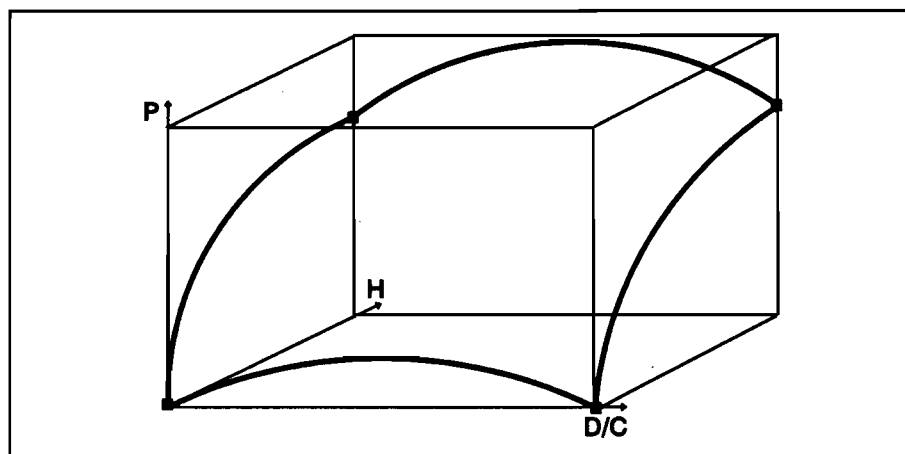


Figure 5. Network performance as a result demand intensity and cohesiveness

The economic rationale of Figures 2 to 5 might in principle be used to make a **comparative** analysis of different countries, different modes or even entire networks. Furthermore, the economic significance of network improvement as a result of European strategies might also be traced in this way.

Unfortunately, there is a serious lack of data on P, D/C and H and, therefore, we have to resort to measurable proxy indicators which mirror only part of the



characteristic features of European networks and may be used as a partial basis for assessment and evaluation of the performance of European networks. Such indicators may relate to whole networks, to separate modes or even to links or nodes. It seems useful to describe the indicators here on the basis of the well-known **Pentagon** model which has been used in earlier studies (see Nijkamp et al., 1993) to identify weak and strong elements in networks and to propose remedial policy strategies (see Figure 6). In this way a broader evaluation framework than a strict economic one is obtained, as also environmental or organisational/institutional aspects can be considered.

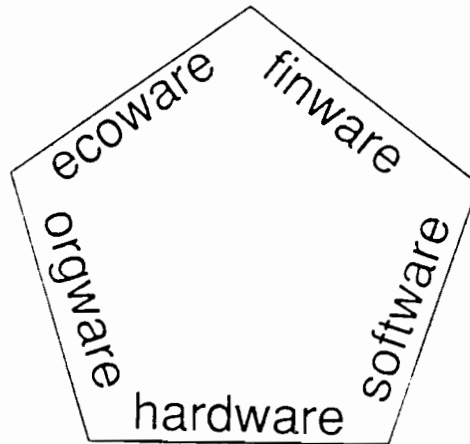


Figure 6. The Pentagon model

By using this prism approach, the strategic factors responsible for a sub-standard functioning of networks and for a lower service delivery compared to its maximum potential can be identified. These services include of course economic impacts, but also environmental and other considerations. The components of the pentagon prism are:

- \* **Hard ware** refers to the tangible material aspects of transport infrastructure. They serve to physically facilitate transport services or flows generated by consumers or firms;
- \* **Soft ware** refers both to computer soft ware used to control sophisticated hard ware and related services like information systems, computerised booking and reservation systems, communication facilities, route guidance systems and so on;
- \* **Org ware** comprises all regulatory, administrative, legal, management and coordination activities and structures regarding both the demand and the supply side in both the private and public institutional domain;
- \* **Fin ware** refers not only to the socio-economic (cost-benefit) aspects of new investments, but also to the way of financing and maintaining new infrastructures, to fare structures, or to state contracts for guaranteed finances for public transport deficits;
- \* **Eco ware** refers to environmental and ecological concerns (including safety and energy questions).

Now, we will for each of these five components successively describe the type of indicators which might be used to analyse the cohesiveness of networks in Europe. This will illustratively be done in a concise tabular form, which includes the three above mentioned major cohesiveness characteristics of infrastructure networks (see Table 1).

An important step will be to translate the characteristics of Table 1 into measurable indicators. This will of course depend on the modes considered, the actors at hand, the regions under investigation, the policies pursued etc. Thus an important task is to design an **assessment/evaluation methodology** for transport network policy-making (cf. Nijkamp and Blaas 1994). This would have to be based inter alia on the following **performance indicators** for both private and public actors:

- productivity gains or added value
- network synergy based on public service delivery to private and public actors
- competitive improvement for firms
- spatial-territorial integration
- technological harmonization
- removal of bottlenecks or spatial externalities (e.g., congestion, environmental stress, road fatalities)
- user possibilities by various specific groups (e.g., small and medium size enterprises)
- financial costs/revenues for public, (semi-) public or private bodies in charge of operating the infrastructure
- contribution to European cohesion
- access and benefits for less favoured regions
- intermodal complementarity
- degree of interoperability
- use of telecommunication technologies (e.g. informatics, telematics)

It should be added that such indicators have to be collected over a time span which would allow for change. Thus some sort of an **observatory** based on a systematic monitoring of information is needed.

### Pentagon factors

Cohesiveness features	Hard ware	Soft ware	Orgware	Eco ware	Finware
I. Intermodality	compatibility of technologies; uniform standards for rolling stock; intermodal competition and complementarity	compatibility of information systems; logistic platforms; informatics services; telematics	management of mainports; design of transfer points	sustainable transport behaviour	cost effectiveness; user charges
II. Interconnectivity	accessibility of terminals or transfer points; access to network modes; standardized technology	tracking and tracing; EDI; telematics	localisation of transfer points or terminals; development of hub-and-spokes systems; Trans-European connections	savings in energy use	efficiency; line haulage
III. Interoperability	advanced transshipment equipment	sophisticated logistics; surveillance and guidance systems; training and education	coordination of transport operations; efficient control; hazardous goods control; local distribution	efficient enforcement of environmental regulations; safety regulations	competitive strategies

Table 1. Cohesiveness characteristics in relation to five critical success factors

Based on the information incorporated in Figures 2 to 5 and in Table 1, we may give an overall characterisation of the quality of European networks by combining H and D/C in one figure (see Figure 7).

In a simplified way we might use a trichotomic-quattrotomic classification to typify the expected performance of networks (see Figure 8).

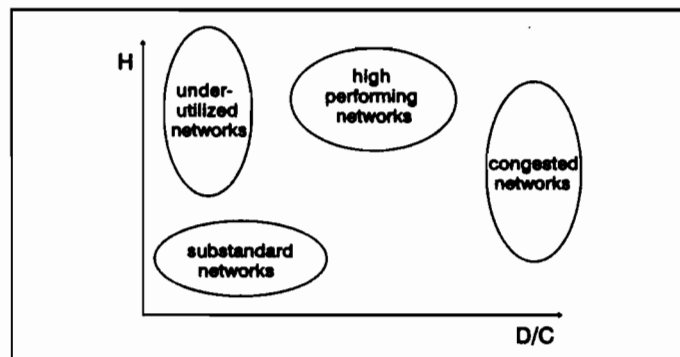


Figure 7. A characterisation of networks

It is clear that Table 1 and Figures 7 and 8 cannot only be used to **map** the features of the structure of European networks, but also to **monitor** its evolution, either as a policy forecasting tool or as a long-run scenario tool ('what-if'). Clearly, the demand side of transport systems is much more flexible than the supply side which is much more inert. This means that for a monitoring study time series have to be available, which cover both the P, D/C and H indicators from Figures 2 to 5.

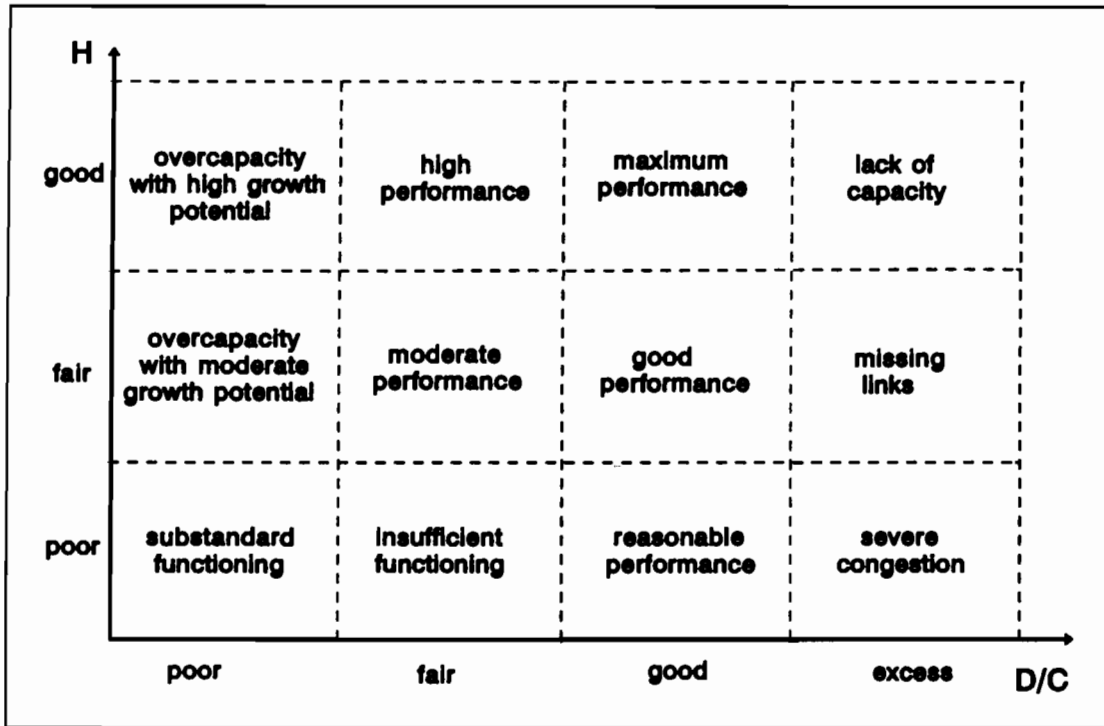


Figure 8. Typology of networks

After the design of a monitoring and forecasting/scenario approach, the **appraisal** of European infrastructure developments is in order. The main task here is the identification and use of **evaluation indicators** and **identification of critical success factors** for improving the performance of European transport systems.

Particular attention would have to be given to evaluating the most efficient and environmentally acceptable package of modes in an international network linking all regions and countries in Europe, while taking into account the potential for various actors of using combined transport, telecommunications and intermodal interchange.

## **5. The European Dimension**

This variety in approaches towards the study of European transport networks shows convincingly that - despite the glamour embodied in the three appealing missionary statements for European transport policy, viz. interconnectivity, intermodality and interoperability - it has to be recognized that there is still a long way to go. Although the needs and potentials of a coherent transportation system for both passengers and freight are widely acknowledged, the current practice offers at best examples of project-oriented modal solutions and hardly any successful implementation of an integrated blend of synergetic transport solutions. There is thus a need for a systems-based evaluation approach that regards the European space as a comprehensive window of transportation opportunities which may generate a substantial value added in a competitive global economy.

### **References**

- Bayliss, B., **Transport Policy and Planning**, The World Bank, Washington, D.C., 1992
- EC, **Road Freight Transport in the Single European Market**, Report of the Committee of Inquiry, Brussels, July 1994
- Nijkamp, P. and E. Blaas, **Impact Assessment and Evaluation in Transportation Planning**, Kluwer, Boston/Dordrecht, 1994
- Nijkamp, P., J. Vleugel, R. Maggi and I. Masser, **Missing Transport Networks in Europe**, Avebury, Aldershot, UK, 1993
- OECD, **Advanced Logistics and Road Freight Transport**, Paris, 1992
- Pesquera, M.A. and A. Ibeas, **Transport Intermodal Chain in European Community Ports**, Paper European Transport Planning Colloquium, Brussels, March 1990
- World Bank, **World Development Report 1994**, Washington, D.C., 1994