EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

The ESPON 2006 Programme

RESEARCH PROJECT ESPON 1.2.1.

on

TRANSPORT SERVICES AND NETWORKS

TERRITORIAL TRENDS AND

BASIC SUPPLY OF INFRASTRUCTURE

FOR TERRITORIAL COHESION

FIRST INTERIM REPORT

by

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Octobre 2002.

I Introduction

The fundamental aim of the ESPON 1.2.1 project "Transport Services and Networks: Territorial Trends and Basic Supply of Infrastructure for Territorial Cohesion" can be developed in three questions: How the transport network may constitute a key factor of a more balanced, more polycentric, more sustainable spatial development? How to develop the accessibility to basic services and to knowledge in order to increase the territorial cohesion? What will be the consequences of enlargement on the preceding objective?

These objectives of the project have to be seen for the background of the main challenge of the ESPON 2006 Programme:

- Identifying the decisive factors relevant for a more polycentric European territory, and the accessibility of a wide range of services in the context or enlargement.
- Developing territorial indicators and typologies capable of identifying and measuring development trends as well as monitoring the political aim of a better balanced and polycentric EU territory.
- Developing tools supporting diagnosis of principal difficulties as well as potentialities from infrastructure network in the field of transport…
- Investigating territorial impacts of sectoral and structural policies.
- Developing integrated tools in support of a balanced and polycentric territorial development.

1.1 Thematic scope and context

Communication and exchange between cities and territories takes place via infrastructure networks where resources, goods, humans and information are exchanged. Access to those networks is increasingly becoming a crucial factor for territorial development and cohesion.

The ESDP has highlighted the close relation between the aim of a balanced territory and polycentric development and the policy orientations developing the infrastructure networks. The ESDP has also highlighted in this respect the special role, which could be undertaken by Euro-corridors, global integration zones, gateway cities and urban poles, well distributed on the European territory, as nodes in the infrastructure networks.

The functioning of networks very much depends on access points: most prominent in that respect are ports and airports, which need to be efficiently linked to land transport modes in line with an organisational network approach.

A travel is always multimodal with the terminal sections: door to door

Furthermore, communication and exchange between networks takes place in multi model nodes. Multi-modal points are becoming increasingly important for sustainable transport in order to be able to use the least environmentally unsustainable transport mode possible.

The major ESDP concept of *"parity of access to infrastructure and knowledge"*, understood as a guideline promoting a better territorial equity or balance… (e.g. for low density areas, ultra peripheral regions, coastal zones, inlands, mountain areas, transnational co-operation areas) are important issues in that respect. It should make the location parameters of the future more clear, including the relative importance of accessibility to infrastructure networks.

The diverse territory of Europe as well as the present spatial structure (with consideration of the polycentric development) indicates the problem of minimum supply of (public and private) infrastructure capable of providing the basic services required in all regions and to maintain the "service of general interest"... However, a basic supply of services represents only the first and minimum step towards the provision of higher degrees of infrastructure.

The aim of complete equality is unrealistic in Europe because the territories and the histories are different but the equity is possible. Transport networks are an element of this.

The interactions between different infrastructure networks and territorial cohesion should be taken into particular account with regard to the growing importance of some EU Member States as transit countries in an enlarged European Union. In general, this project shall provide input for the territorial impact analysis of TEN policy under ESPON action 2.2.1..

1.2 General objectives

So, the general objectives of the project are:

- To contribute to balanced and sustainable spatial development and territorial cohesion.
- To contribute to the identification spatial structures of the EU territory, in particular the degree and diversity of physical and functional polycentrism at different geographical scales.
- To define concepts and to find appropriate territorial indicators, typologies and instruments as well as new methodologies to consider territorial information linked to polycentrism, to detect territories most negatively and positively affected by the identified trends with special reference to regions in terms of accessibility, polycentric development, environment, urban areas, territorial impact assessment; particular attention will be paid to areas exposed to extreme geographical positions and natural handicaps in a global or world-wide context.
- To develop possible orientations for policy responses.

1.3 The team

For studying these questions and producing recommendations in the field of transport and planning policy, the Transnational Project Group ESPON1.2.1 "Transport services and network: territorial trends and basic supply of infrastructure for territorial cohesion" is organised around a compact team: CESA (France), INRETS (France), S&W (Germany), MCRIT (Spain), NESTEAR (France) and UMS RIATE (French contact point).

Team members have made key contributions to the Study Programme on European Spatial Planning, particularly in the Working Group 1.1 "Geographical Position".

Each project partner is a specialist on a particular domain and will contribute in team work to issues of passenger transport, freight transport, spatial consequences, service based approaches and hyper cartography. Generally speaking the subjects treated by the various partners will be the following ones:

- CESA/INRETS: Quality of transport services, multiscale, multilevel, representations
- NESTEAR: Goods transport.
- S&W: Passenger transport
- MCRIT: Spatial consequences of transport systems
- UMS RIATE cooperation with other themes (1.1.1, 1.2.2, 2.1.1 and 3.1)

However, the common approach integrate the various transport modes; road, rail, inland and sea waterways and air and consider the possibilities of intermodality and mode transfer at various geographical scales.

Each partner is responsible for one or several interim reports each involving a synthesis of the different domains. The final report will be a global synthesis elaborated with the coordination of the CESA-INRETS, lead partner of this project. The dissemination, the contacts and the cooperation with the other themes will be done by the UMS RIATE, the French National Focal Point of ESPON.

The ESPON 1.2.1 core team is supported by a set of consultative partners having a role of thematic and/or territorial expertise for a complete geographical coverage on the whole European territory, including candidate countries (EU 27)

- Peter W. CARDEBRING tfk-hamburg..
- Paola PUCCI, University of Milan, Italy.
- Dimitrios TSAMBOULAS University of Athens
- Umberto PETRUCELLI, University of Basilicata – Potenza - Italy.

They will bring their competence for obtaining data and, for validating results in their domain of geographic specialisation. Their scientific headways will also benefit the team of and will allow then to enrich the whole work (the conclusions and the solutions will be elaborated in common).

1.4 The 1st Interim Report

The consortium has as its aim to develop and implement indicators that are efficient, dedicated to assessment, to monitoring and to prospective in the domain of transport networks and services, and which are able to be used as inputs for the production of recommendations in the field of transport and planning policy with clear political scope.

The 1st Interim Report is a starting point for this objective. It will discuss the political challenges of the project (Chapter 2). It will review existing indicators describing transport networks, services and accessibility (Chapter 3). It will then present an outline of the proposed concepts and methods to develop and implement a set of indicators to be demonstrated for Europe and its regions (Chapter 4). Data requirements deriving from that and cooperations with other projects are addressed (Chapter 5). Expected results of the project are outlined (Chapter 6). Conclusions are given in form of key issues (Chapter 7)

Chapter II Policy scope: key Issues

2.1 The general policy context

ESPON project on transport network and services "has for major objectives to improve the decision support tools so that policy makers can more easily find the proper ad equation between policy goals and transport policy measures. Therefore the policy scope and key issues related to it must be analysed and discussed at preliminary stage of the ESPON project.

However it is also clear that it is not easy to define precisely this policy scope, because transport is closely related to many economic and social activities and rarely justified as a final "product" : transport policy interfere with many other policy objectives so that it is difficult to present a consistent framework for transport policy objective as a whole. Transport has economic, financial, spatial and social dimensions and all of them must be taken into account in this policy scope.

Another difficulty of such an analysis is the institutional context dimension of the problem : transport is a sector of fierce competition between companies across the world, in sector like maritime or road transport, but in the same time it is also a sector of strong intervention of public organisations, and in particular for the promotion of public transport for passengers. This means that decision makers have quite different systems of reference for transport operations and transport performances and such disparities must be taken into account when considering decision making processes and decision support systems.

At the international scale the evolution of European institutions in transport regulation will then be a focal point of interest for this research work.

This has several consequences :

- first that national institutional level must be considered in parallel with an increasing role of European role for market regulation but also for infrastructure implementation : opening to the East with integration of ten new member states, Euro-Mediterranean policy, connection with new neighbouring states of Russia, Balkans and Central Asian countries cannot be forgotten ; in market regulation, environmental concern brings more and more constraints in order to limit negative impacts on environment
- but also that the increasing role of local institutions must be taken into account, whether they are communes, groupement of communes or regions ; decentralisation, and "subsidiarity" principles which are parts of many national policies and European policy recognise and favour such evolution making the decision process more complex and influencing the definition of decision tools.

In a general way one can say that transport is becoming a more and more sensitive problem from a political point of view, which implies that transport will be more present in the democratic debate. Transport major issues and transport major projects, including infrastructure projects must now give rise to a democratic debate before the final decision is made, and the solution is rarely in the hands of a single institutional organisation : it results from different institutional cooperation at national, international and local level, with more and more often participation of citizens. All these elements must be parts of the policy scope and framework in which the project on “transport network and services” is integrated.

Being aware of all these dimensions of the problems, the present document certainly does not ambition to address all these aspects and can refer to many research publications which have treated this problem in the IV and Vth framework research programme :

- TENASSESS and CODETEN have addressed the problem of transport policy in relation with infrastructure development
- FORESIGHT is an on going project which considered the relation between transport and non transport policies. EUNET and SASI have proposed accessibility indicators for regions
- Several transport scenario projects (SCENARIOS, SCENES, TEN priority corridors) have included for Western and Eastern Europe policy objective scenarios.
- ASSEMBLING focussed on the definition of transport observatory, and classified policy indicators relevant for transport. INFOSTAT, and ETIS relative to information system in Europe have also included as well as CONCERTO, ATIS, ALPNET for the Alpine region.

Finally from DG Regio side the relevant project on cohesion and GIS on which ESPON programme has been based must also be referred to

The aim of this document is then to give only few selected elements of transport policy context and refers to more recent policy statements of EU Commission mainly the White Paper in transport policy (and the related proposals for the TEN review) published in autumn 2001 as well as recent considerations about the ESDP (Europe Spatial Development Programme).

This document starts indeed from the basic assumption that there has been mainly two different approaches in the policy scope of transport policy, which have been largely independent in their definition and their context. Although efforts have been made to make them compatible, the institutional organisation both at national and EU levels made it difficult to reach a good coordination between these two approaches.

At the EU level the White Paper have been prepared by DG TREN and is mainly focusing on market regulation, with only few considerations about the spatial impact of the measures proposed) DG TREN has indeed no legitimacy to address regional policirs and transport market rules are general rules which have to apply to a large diversity of regional situations. When dealing with infrastructure development, then the geographic dimension is certainly included, but each project will then refer to specific studies and coordination context with the member states ; so far it does not really refer to a spatial policy but just to general interconnectivity, interoperability, intermodality considerations.

On the other hand the DG REGIO is first concerned with regional development, cohesion policy. Although the spatial development objective of European space is not part of EU domain of competence there is an increasing convergence between members states to develop a common understanding of European spatial development. The inclusion in the Maastricht Treaty of TEN network tostrengthen European cohesion has certainly help in this mobilisation and new ten guidelines in 2004 should be a new step towards European spatial development. So far interventions from DG REGIO were mainly justified through structural funds policy, where regional approaches are privileged. Although in structural funds transport operations have taken an important share it was sometimes difficult to link these operations with the general transport policy ; they concern more capillarity networks, specific accessibility problems, local and regional objectives and were not intended originally to meet these general transport objectives. With the cohesion funds related to transport projects it became more and more difficult to distinguish between local or regional objectives and European policy : major infrastructure links, in particular in Spain have been substantially funded with cohesion funds ; they improved major European connections, and had a clear direct European scale impact.

Tomorrow things will become more and more interrelated between transport and regional and spatial policy :

- because ESPD Scheme become more and more a reference for policy makers and co-decision procedure consultation of regions through the Committee of regions and the European Parliament will probably strengthen this tried : and ESPD is clearly related to TEN development and consequently to TEN operating system and therefore to general transport policy regulation
- because the EU enlargement put forward the problem of extension of TEN network to the East ; already during the transition period the TEN priority corridors (Crete conference) have become a central reference to CEEC national planning scheme : today extension of TEN towards the Balkans region (Strategic network for Balkans of the Commission) and Mediterranean area is also considered : the PETRA of Helsinki conference were a first scheme of Mediterranean corridors which will now analysed in depth in the new MEDA programme ; for these operations there will be a clear mobilisation of all financial means of EU.
- Because of the necessary renewal of structural funds policy with the stakes of the definition of new EU institutions (results of EU convention).

Consequently it is very important to “bridge” the transport policy approach of the market regulation with the regional approach of the European space, and the ESPON project on “transport network services” will mainly focus on this point in order to be able to construct relevant decision support tools for policy makers to facilitate dialogue process and emergence of solutions.

European transport policy goals, aims and actions

Policy goals	Policy aims	Policy actions
Economic and technologic competitiveness	Promoting Economic growth Inducing Market efficiency Assuring Fair competition Supporting technologic development More balanced spatial development More homogeneous economic endowment (transport...) Legal harmonisation Protecting natural biodiversity Renewing resources Improving environmental quality Increasing human safety	Legal regulations (deregulation, liberalisation...) Planning documents (TETNs, Europe 2000+, Towards Sustainability...) Investment programmes (loans to specific infrastructure projects) Subsidies

Policy aims

Growth	Sustainability	Cohesion
TRANSPORT POLICY AIMS		
Market conditions for provision and management of infrastructure (transport impact on growth through improvement of private investments profitability)	Apply the "polluter pays" principle and adequate payment mechanisms	Provide adequate access to social and economic opportunities for all European inhabitants
Fair competition between modes	Introduce global and long-term considerations in transport planning (Strategic Environmental Analysis)	Facilitate the development of international trade and mobility to enhance economic and social integration within the single market
Make long-distance and international transport costs equivalent to those in competing areas (USA, Asia...)	Apply Environmental Impact Analysis	Use the design and implementation of major transport investments to enhance social cohesion
Maximaze economic returns on investment, operation and maintenance of the multimodal TEN		Help the accession of the CEEC and the economic development of neighbouring areas (Mediterranean and CIS areas)
Internalise network cost and benefits effects on project appraisal, in particular in cross-border areas		
Stimulate multimodal chains		
Integrate EU in world logistic trends		
Provide adequate links between long-distance flows and their local and regional components		
SPATIAL DEVELOPMENT POLICY AIMS		
Dynamic, attractive and competitive cities and urbanised regions	Polycentric urban development: A Basis for better accessibility	Efficient and sustainable use of infrastructure
An integrated approach for improved transport links and access to knowledge	Indigeneous development. Diverse and productive rural areas	Natural and cultural heritage as a development asset
Diffusion of innovation and knowledge	Urban-rural partnership	Preservation and development of the natural heritage
	Creative management of the cultural heritage	Water resource management
		Creative management of cultural landscapes

ENVIRONMENTAL POLICY AIMS	
	Better land-use planning
	Better infrastructure investments
	Infrastructure charging: road taxes and different forms of road pricing
	Progressive technical improvement of vehicles (exhaust and noise emissions, fuel consumption, performance, final disposal)
	Driver information and education in car use
	Improved public/collective transport
	Discouragement of road traffic in cities
	Development of economic and fiscal incentives (car pooling, positive discrimination of car poolers)
	Development of interactive communication infrastructures
	Composition and consumption of fuels: alternative fuels, cleaner fuels, complete move to unleaded petrol by 2000

TENs Aims	Competitiveness	Cohesion	Sustainability
Inducing multimodality	Productivity improvements by better modal specialisation (adaptation of each mode to its comparative advantages)	Intermodality in EU hubs will facilitate better accessibility from peripheral areas to larger EU markets.	Potential increase of traffic attracted by environmentally friendly transport modes (e.g. rail in relation to road for medium distance trips in the center of Europe).
Citizens networks (local-regional connections to TENs)	Improvement of access to TENs, making TENs more profitable and facilitating a better use of TENs excess of capacity for regional traffic, when feasible.	Accessibility difussion to larger landlocked areas through regional capilarity	Land-taking reduction by using existing excess of capacity of different scale networks
Fair pricing	Capacity optimisation on congested TEN links	Subsidies to peripheral relations can become explicit	Internalisation of the external costs of transports.

Strategic Policy Goals

GOALS	Main Policies	Main conventional indicators
Economic and technologic COMPETITIVENESS	Community Competition Trans-European Networks Research and Development	GPD growth GDP growth by sectors Aggregation: CBA (Cost-Benefit ratio) in financial and economic terms (...)
Social and political COHESION	Structural Funds Common Agricultural Policy	GPD distribution by groups (regions and income groups). Development "gaps". Aggregation: CBA by sectors and regions, in socio-economic terms Multicriteria analysis for non-monetary elements (..)
Environmental SUSTAINABILITY	Environmental policy	Reduction of externalities costs in terms of GPD (safety, land-taking, pollution...). Cost of externalities in terms of of GPD. Aggregation: CBA including the cost of externalities. Muticriteria analysis for non-monetary elements (...)

2.2 Major transport policy objectives

The major transport policy objectives have been recently expressed from the Commission point of view in the recent White paper called "European transport policy for 2010 : time to decide".

In doing so the Commission stresses a certain number of orientations and delimitates (precises) its domain of intervention : it is clear that European market regulation should take in the future more and more importance over national market regulation, but in the same time the application of subsidiarity principles for regional and national interventions is also reaffirmed. For external relations, with countries outside the European Union, the document claims a stronger coordination and a more extensive representation of the Commission in order to present a common position for all member states.

This evolution is indeed the intention to launch a new step in European transport policy, with a stronger political will, in order to progress in the direction of liberalisation and harmonisation.

The proposals made by the Commission are based on a diagnosis which is a kind of mixed diagnosis which point successes and failures of the past European policies.

An important success is the opening of the market in many transport domains although the open access is not yet a reality for all the modes and in particular for rail. Failures are increased congestion and a domination of road with its impact on environment.

The major orientations can be summarised along the following lines with special focus on environmental impacts and sustainable development

- to continue a policy of liberalisation, but also to progress in parallel with measures of harmonisation
- to promote alternative modes such as rail transport, inland waterways and short sea shipping in order to rebalance modal shares
- to eliminate the bottlenecks and give a new impulse to development of transeuropean network.

Safety, promotion of new technologies, improved participation of users are also strong points of the EU orientations, which have a global impact on transport performances but not obviously an effect on spatial distribution of activity. Rationalisation of urban transport is also mentioned but it is clear that this aspect of transport policy is more relevant to local authorities.

Some figures are given in the document about the expected traffic growth per mode, with an elasticity which will be still higher than 1 as regards GDP. Global quantitative objectives are mentioned concerning possible influence on traffic growth or modal shift, but these objectives remain fairly general and are not detailed in the way which would pointed changes in flows distribution and spatial impacts.

The document published in 2001 is certainly a comprehensive approach of transport sector but is expected to be completed by a more detailed one relative to proposals concerning the TEN (published soon after), a document on pricing (expected to be published in 2002) and more detailed studies on the traffic forecasts.

2.2.1 Liberalisation and harmonisation: the market regulation

Liberalisation has been the "master word" for the implementation of the single market in transport. Liberalisation has progressed in the nineties in road sector and air sector but it is not yet achieved for the other modes :

Increased competition in road transport has led to a reduction in prices, increasing the competitiveness of road versus the other modes

Progresses have also been made in air transport with predefined steps leading progressively to an open air market

Inland waterways have made clear progresses towards liberalisation although it starterd later than the two first modes adaptation of the fleet was considered in parallel as an accompanying measure to give a new competitive impulse to inland waterways supply.

Maritime transport, between EU member states and within EU states (short sea shipping) is also liberalised but the concept of public service to serve the islands has still to be preserved

Rail transport was probably the most difficult mode to liberalise : because there is a closed direct link between rail operators and rail network, and because rail companies have been closely linked to the national states and administrations, a whole strategy of liberalisation had first to be set up : what decision to take about infrastructure management ? Should it remain public or not ?

The example of rail shows clearly that liberalisation cannot be the sole orientation and that more precisions had to come about market competition and regulation. The White Paper has been prepared to answer to this question introducing in the same time more room political choices and decision : "time to decide" means also more political choices in order to promote sustainable development. In this document some dangers of an excessive liberal approach are stressed related to the domination of road and increasing congestion with the negative consequences in environment : although "free choice" remains a basic principle with fair competition, this is not clearly sufficient :

- Liberalisation does not mean necessarily privatisation but competition rules must prevail between companies for private and public services
- Progresses must be made in parallel on the harmonisation front : this concerns taxes (petroleum taxes) which still differ considerably from one country to another but also social rules such has working or driving hours ; these types of rules have also an impact on safety and reinforcement of their application is necessary
- For rail but also in a more general way for ports, airports, terminals a major distinction is made between infrastructure management and transport operations ; liberalisation means also "open access" to the network as it has been decided for many other "network services" so that the "rail model" in Europe significantly differs from the "rail model" in the states. With a clear separation between infrastructure management and rail operation an "integrated solution" of privatisation of rail is not the orientation which prevails in Europe. Specially after the difficulties UK experiences had to face
- An important point is made on pricing and in particular in pricing the use of infrastructures ; after the discussion on Eurovignette, a tax per vehicle/km is now the orientation with different systems being experimented, being aware that some states have already a toll system generalised for their

motorways. If the principle of internalisation of external costs is reaffirmed with strength, the choice between "social marginal cost" pricing and "total cost pricing" is still not very clear ; some experts have pointed out that the choice of "social marginal cost principle" might turn out to favour road versus rail, and that in any case the principle of pricing was not neutral as regards modal choice.

- For sensitive areas (limited in the White Paper to "Alps and Pyrenees) cross financing of investments of infrastructures is proposed in order to shift resources from road to rail or from more pollutant solutions to less "pollutant" solutions ; in this case the Swiss model is taken as an example and this has certainly a consequence on pricing.

In other words more importance is given to long term choices with also more stringent norms for safety and protection of environment, which in turn has an impact on operating costs, infrastructure costs and on market regulation. From a spatial point of view this will not be neutral with in particular the fact that the cost of access to periphery might increase with the distance travelled in the case of a pricing of infrastructure proportional to the distance. The spatial dimension was not stressed in the White paper, as mentioned before, but the consequences of market regulation on the spatial development will be an important point of analysis of this ESPON project.

2.2.2 To shift the balance between modes

When looking to the past trends, as well as to trends projections it is clear that rail transport is marginalized.

In long distance and in particular for transport between continents air transport and maritime transport play a major role.

These evolutions have negative consequences for environment and congestion. Enlargement of Europe to the East and transition in CEEC countries give a new impulse to transport growth and to equipment of households with care, which again play in favour of road.

Therefore the Commission would like to be active in favour of alternative modes to road for passengers and for freight.

For passengers it is then important to stress that most of the volumes of transport are short distance : more than 80 % of the traffic is short distance, for distance lower than 50 km concerning regular trips, which are not only working trips but mostly short trips related to social life, shopping, education, urban sprawl has certainly increased to average distance of such trips which remains in the sphere of urban and suburban spatial organisations. From this point of view there is no clear reason why economic growth should automatically imply transport growth since most of decisions to live in suburbs are related to the cheaper price of housing, with the price of land decreasing with the distance from the centres ; for passengers "decoupling" will probably find part of an answer in relevant local planning.

Concerning the modal shift for passengers, this will also be related to a good understanding of the relation between land use planning and supply of public services. Till now supply of public services in areas with lower densities, in suburbs or rural zones remain costly solutions since light, flexible and more individual systems are not yet developed.

The orientation to favour public services and transport closer to citizens is strongly reaffirmed in the White Paper but this domain is a privileged field of intervention of local authorities and any actions of the Commission are limited from the financial and regularity point of view.

For freight the proposals of the White paper intend certainly to go beyond declaration of principles, or specific actions of promotion ; a whole set of possible actions is reviewed

- first to revitalised rail and promote intermodal transfer
- to promote short sea shipping and inland waterways

2.2.2.1 To revitalise rail and promote intermodal transport

Revitalisation of rail requires first the creation of a genuine internal rail market.

So far rail markets have been mainly national markets with national, historical companies, but also national equipments, norms, operating systems. There is today a paradox, since one would expect rail to improve its modal share on longer distance market. The opening of economies should favour rail transport. But this is not the case because with longer international trips the number of border crossing increases with the necessity to change, most of the time, the driver, the locomotive to face new operating system for reservation of the slots, to adapt to new commercial practises and administrative procedures : these are “interoperability” problems rail has to solve in European transport, when interoperability problems for road can be overcome much more easily.

All these facets of interoperability, plus the aspects related to the principles of rail “open access” mentioned earlier are parts of the European strategy to revitalise a rail market.

This revitalisation of rail goes in parallel with the production of “intermodal transport”. Although formerly intermodal transport also includes some short sea shipping techniques we will limit ourselves in this chapter to rail/road techniques.

In order to well understand the problem of intermodality and its spatial dimension, it is important to proceed with the following distinction the White Paper has not clearly pointed out :

The maritime container market for intercontinental trade:

This traffic is distributed throughout Europe by sea (“feedering” which is one part of the European SSS market) or by land modes, intermodal land transport is the continental leg of an intercontinental maritime transport. This type of transport is a dynamic market for intermodal transport in particular for serving major European “hub” ports, when large container vessels stop. Block trains or shuttle trains of maritime containers penetrate along transport corridors the interior of Europe, to intermodal terminals when the container are distributed (or collected).

The combined transport

The combined transport is combination of rail and road modes with a transfer of a load unit : swap body or semi-trailer (piggy-back technique). These techniques are used for long distance national and international traffics : most of the international combined transport in Europe is for traffic across the Alps. Combined transport is a privileged technique for crossing “sensitive” areas and in particular mountain chains when long road tunnel might be difficult to build and operate, or might create important nuisances to the environment.

The use of intermodal techniques require investments in terminals, maritime terminals and inland terminals : the development of these techniques means also the development of a network of terminals in Europe as part of the infrastructure networks.

In the organisation of such transport chain, inland waterways can also be chosen as a mode to be combined with maritime or road transport : intermodal inland ports are also parts of intermodal network. The problem of development of “rolling road” is however somehow different : rolling road technique is the transport of a truck on a train including the tractor. It is generally not considered as an intermodal technique because the organisation of the transport chain is not changed ; the transfer is most of the time for a short distance link to cross a sensitive area where road link has no sufficient capacity or when road profile is not adapted to heavy transport. If one advantage of rolling road is often easy and fast transhipment, then one major disadvantage is the transport of “dead” weight (tractor and trailer) the payment of truck driver during rail transport (if the time is not accounted as resting time) so that rolling road services are limited to links where road face very difficult conditions for operations (physical or restrictive administrative measures such as transit authorisation).

This segmentation of the intermodal transport indicates then the conditions and privileged places where they can develop in European space.

2.2.2.2 Short sea shipping

More recently short sea shipping has been added to these intermodal techniques as an alternative mode to road including the feedering services mentioned earlier. Short sea shipping using containers for intra-European transport market also exists with container norms which are not necessarily compatible with international ISO norms : however such services are so fare limited to North Sea services and it is still early to say what success this technique will meet, and what progresses can be made for harmonisation of these container norms.

Therefore the privileged market segment for SSS within European trade market is certainly the transport of semi-trailer or swap bodies on the deck of ships (or on trailers) : such techniques should be in direct competition with road transport, largely based on “ro-ro” techniques.

However this market in Europe is not yet very much developed except in Baltic Sea, some relations on North Sea or in the Adriatic between Greece and Italy, keeping in mind that SSS is, with air, the sole mode to serve Islands.

In Mediterranean some experiences have been made in particular with ROPAX vessels and studies are made to investigate this potential market. In the White Paper several measures are envisaged to promote such intermodal techniques, to stimulate technologic development, to adapt administrative procedures in particular in ports, where transhipment still requires much time and where adapted equipments and infrastructure must be planned.

In this strategy of European Union, efforts will be made on demonstration cases, on the mobilisation of concerned actors and on subsidies to launch new services : following and extending the PACT programme, with a much larger amount of public funding, a Marco Polo

Programme will be launched.

2.2.3 The implementation of TEN network

Implementation of TEN network is also a major aspect of the European transport policy which has a direct spatial impact on European space.

However the spatial dimension was not necessary the initial approach of the transport policy relative to TEN network, although it could not be obviously be disconnected from the spatial dimension ; this is where transport policy takes a concrete spatial dimension and this is why it is useful to recall some steps of the TEN transport policy in order to better understand this articulation with spatial policies.

First the transeuropean network concept was first developed in transport policy before it was mentioned in Maastricht Treaty as an important aspect of the cohesion of an European space.

Two types of European network were prepared :

- a HST network as a symbol of new services in Europe, linking major cities from different states with much shorter time than previous conventional rail, using new rail technologies
- a combined transport network with the objective to identify corridors when the volume of demand and the length of trips should be sufficient in order to promote a competitive service with road.

The Maastrich Treaty gave a new impulse to the concept of TEN network which was including also energy and telecommunication networks.

From the transport policy this gave rise to :

- different modal TEN European networks for road, rail, inland waterways with for rail a conventional rail network in addition to the HST network.

Such rail network should irrigate the European regions. Concerning the air transport a network of airports was defined including different levels according to the role of the airport in international, European and national services. However it was not possible to introduce such a typology for ports because of the competition existing between them and the ports mentioned were more a list of ports than a structured definition of a port European network. For inland terminals the same type of difficulties arose and the TEN proposals for infrastructures tended to be more a juxtaposition of national schemes than a genuine European network.

- an effort to build an European intermodal network stressing intermodal solutions and including basic principles relative to efficient use of such network from an economic but also an environmental point of view
- definition of priority corridors in CEEC countries which should extend the TEN defined for the European Union
- and finally the definition in the TEN of priority projects (so called the Essen projects) with among them many major projects of interconnection between states in order to strengthen a European scope of such networks.

The recent White paper must then also be understood as a document in the process of definition of new guidelines for the TEN network in 2002 in relation with the Parliament. The White Paper was completed by a document relative to this process of adaptation of the TEN and of their criteria for definition of priorities.

Among the objectives for priority the removal of bottlenecks are stressed including with an improved management of infrastructures use.

For rail freight the concept of “dedicated rail freight” network is proposed. This concept has been discussed in several countries with the objective to grant more priority for freight train in the slot allocation : the reason is that quality of service of freight trains are very poor because of the difficulty to get adequate slots along the train routes and that rail will never be competitive against road unless the situation changes and freight train can be better programmed.

The complementarities between HST and air are also stressed so that more flexibility can be introduced in the management of air capacity, developing new intermodal chain for passengers.

Concerning priority projects, new proposals have been made in addition to the Essen priorities including new lines for HST and freight in Italy, France, Germany and Spain as well as a project on the Danube and a new fixed link between Denmark and Germany ; improvement of satellite navigator and interoperability is also put forwards.

The question of funding this project is certainly not solved but new perspectives are open as far as a possible increase in European contribution and possibility of cross financing, keeping in mind opportunities of private funding when possible.

Among the criteria to be promoted there is a criteria of accessibility but at this point it is also to give a different approach of the transport problem, the approach which privileged the spatial dimension from regional or European spatial development point of view.

2.3 The spatial approach of transport

The spatial approach was rarely presented as such as the European level.

At local level such approach does exist for a long time and in particular in urban planning although a clear understanding between land use pattern and mobility was not always obvious : progresses are made in this direction.

At national level, infrastructure scheme does take into consideration problems of accessibility of regions or accessibility of remote areas included islands. Through national master plans the national spatial policies are somehow “internalised” but there is no guarantee at all of an overall European consistency, from this point of view ; some master plans privileged uniform principles of accessibility, but others stress the criteria of financial or socio economic return making a clear separation between transport and regional development. In France for example there is an history of “aménagement du territoire” which is not shared by many other European countries.

At European level an initial concern was regional development in order to reduce the gap between regions and to help regions with lower income to catching up. The structural funds policy was refined including redeployment of old industrial places and stimulate transborder cooperation : in all these actions transport projects take often an important place. The initiative of a “European spatial development perspective" which was an informal perspective proposed a more global approach which is in line with an objective of bringing more cohesion in Europe : transport network have been considered as a way to reinforce cohesion and several important transport projects of peripheral countries have been partly financed by cohesion funds.

Therefore it is important to understand how transport has been included in the spatial approach of Europe so that the links between spatial and transport objectives can be strengthen.

2.3.1. European spatial development perspectives and the polycentric development

The polycentric development concept is central in the ESPD. It is a more sophisticated understanding of the relationship between places as the simple core-periphery opposition. The guidelines of EU spatial development from the concept are :

- Development of a polycentric and balanced urban system and strengthening of the partnership between urban and rural areas
- Promotion of integrated transport and communication concepts, which support the polycentric development of the EU territory and are an important precondition for enabling European cities and regions to pursue their integration into EMU
- Development and conservation of the natural and cultural heritage through wise management.

Therefore the polycentric concept proceeds from an in depth analysis of "functional interdependencies of urban areas within a region and across administrative boundaries ; this will include "local transport, waste management and the designation of shared residential or industrial areas".

Furthermore the relationship between urban and rural areas, as well as the way to access to EU territory and to world trade should be also stressed so that these metropolitan areas are also internationally accessible : the polycentric zone should be also "global economy integration zone" pointing cities clusters and networks of smaller towns related to them to form viable markets with adequate economic services and institutions : from gateway cities or ports there is a distribution of functions which take also into account a balanced development of rural and urban areas.

Starting from this "bottom up" scheme of socio and economic relations, identified in the space the polycentric framework will include :

- settlement structure of urban places offering different levels of public services : pointing major growth points and development axis
- location of infrastructures and routes as well as nodal points, distribution centres, logistic facilities
- economic structure of the region with location of different types of accessibility
- the open space structure which will allow expansion but also point relations with neighbouring regions ; EU market and world economy.

Such an approach will certainly imply the transport as a major component of polycentric development, but in the same time the diversity across Europe of such polycentric zones according to the historical development of cities and rural areas, and their location in European geography along major routes or close to a port, within densely populated areas or not, with more or less sensitive areas from ecological point of view (example of mountains areas).

The polycentric development can then be considered as a goal to be reached for spatial and transport policies, in an attempt to understand as deeply as possible the local context of development in relation with globalisation ; however the European spatial policy has been so far implemented with more global and uniform criteria within the framework of structural funds policies and cohesion policies.

2.3.2. Structural funds policies

Structural funds policies have developed progressively in a process of "deepening" a European policy, mainly after the accession of poorer southern regions of Europe : first the south of Italy, then the integration of Spain, Portugal and Greece (not forgetting Ireland in the north with also a lower income per inhabitant).

The main objective was to help regions with lower income to catch up with European average : therefore indicators had to be set up with sector based policies for sectors which have specific market regulation problems (agriculture) or problems of redeployment.

Structural policies, sector based policies have then an obvious spatial impact which has to be taken into account.

In structural policy programme transport investments have often been pointed out as important investments for catching up with the objective of improvement of local and regional transports considered from the local and regional point of view.

If in the beginning of the structural policy, the average income per inhabitant was the indicator chosen for access to such support (objective/mainly) then more specific interventions were possible to support local economic structure, face redeployment, unemployment or social specific problem : in doing so most European countries for some well identified areas and specific purposes could also accede to structural funds also the national or regional income average was higher than the European average : however these "second wave" funds for intervention were more limited than the funds granted for "convergence" purpose in terms of average income.

In a third phase "interregional" problems have been stressed and in particular across the borders, including across borders with countries which are not EU members.

INTERREG interventions also included transport approaches since border crossing has been for a long time a major obstacle for the smooth functioning of a transport chain : lack of continuity and coordination of services provided, missing links, interoperability problems which prevent efficient public transports and often very heavy administrative procedures. Local services across administrative and natural boundaries were included for passenger traffic, facilitating transborder communications, but also analysis of "Eurocorridors" across Europe.

Today INTERREG programme extends to more comprehensive approach of large "Euroregions" and again, transport services including land and maritime transport services can provide adequate approach within such programme.

Since the opening to the East, structural funds policies have been extended making Germany a beneficiary of such policy after the integration of eastern länder ; further East new INTERREG programmes were set up with candidate countries.

Concerning sector based policy the evolution must also be stressed because of their impact on space and on the understanding of interdependencies between different types of space : PAC policy for example is not only turned towards subsidies to product but also to rural area development.

2.3.3. The accessibility concept in spatial development

The objective of a general document on policy scope, is certainly not to discuss different accessibility indicators and the way to measure them : this will be done in a specific contribution on this topic.

It is to stress different understandings of accessibility as regards the spatial equilibrium objective which has been mentioned earlier.

One first difference to be made is certainly between local or regional accessibility and interregional or international accessibility.

In a regional or local accessibility short distance relations must be investigated which means the relations which reflect the regional interdependencies and conditions of exchanges between rural and urban areas.

However short distance relations can also be a terminal leg of a long distance transport chain : from that point of view it appears that cost and time of the terminal leg represent an important and growing percentage of the total cost of transport.

In this assessment distance is certainly a factor which increases transport cost, but on the other hand time is also an important factor and time of transport is increasing in dense congested areas which often are central areas. The conclusion is that the traditional opposition between centre and periphery must be reviewed and certainly refined so that the concept of polycentrism can be properly introduced in an accessibility analysis, taking into account local accessibility and long distance accessibility as well as possible combination of transport “legs” which are parts of a door to door transport chain : for the final user it is the door to door performance of transport which finally counts.

In the spatial analysis conducted in the ESPD as well as in the regional development policies, the importance of European network has been stressed in the Maastricht Treaty transeuropean networks are considered as an important aspect of European cohesion and it has been seen that the TEN network will extend to CEEC countries (ten priority corridors), to Balkans (Strategic network of the stability pact) or to Mediterranean region.

But in the same time, other distinctions must be made between dense areas facing congestion, remote or deadlocked regions with poor accessibility and peripheral regions.

Among the peripheral regions, many of them are maritime regions, and this is why it is also necessary to include maritime relations, not only for intercontinental trade but also for relations between European regions or between peripheries.

In conclusion the spatial development analysis had to adapt to specific context and European diversity requires at the same time more complex transport analysis in terms of multimodality and intermodal solutions. Infrastructures are not the unique answer to this problem of accessibility and the availability of services, the quality of services must also be considered.

From now the interrelations between regional development, spatial analysis and transport are strong and both approaches, the spatial and transport opposite, must be combined in a more efficient way.

It is on this interrelation that the task network and services will concentrate in order to adapt the decision making tool and the use of GIS.

2.4 To bridge transport and spatial policies

Although the international organisation of institutions always introduce some rigidity in the decision system with on one side transport competence, and on the other side spatial policies at all decision levels whether they are national, regional or European there has been progressed on both fronts towards a better understanding of the role of transport in spatial scheme.

When looking at the last White paper proposals it is clear that there are opportunities for a more balanced spatial development ; concrete experimentation can be launched in close relation with regions.

But in the same time the diffusion effect of these experimentations and the development of a spatial policy is also a problem of a good understanding of the role of the different actors in a long term planning process.

2.4.1. Opportunities of transport policies

Such opportunities have not been so far presented in terms of spatial planning process but more as propositions to solve transport problems which are related to congestion and impact on environment.

Therefore alternative transport modes and transport chains are promoted bringing a wider range of potential services and therefore opportunity to adapt to a diversity of regional context.

This is for example the case for the promotion of maritime transport which can give a new impulse to peripheral maritime regions. Intermodal transport opens also the opportunity to combine performances of rail on long distance and performances of road on shorter distance. But these opportunities and a broader range of services call for more sophisticated transport solutions. Rail transport, intermodal transport, air transport require an organisation of concentration of traffics on nodal points as well the organisation of a distribution across regional space ; the result might certainly be more satisfying in terms of impact on environment or, possibly, costs of transport but the solution is obviously more complex than a straight road service, door to door, which is very flexible.

In other words there are new opportunities open within programme such as Marco Polo for maritime transport or intermodal transport, but this would rely on a good understanding of the role of decentralised units such as regions as well as the setting up of a long term decision making process.

2.4.2. A new role of regions and local institutions in transport organisation

When the transport supply is presented as a transport chain from door to door with the objective of development of alternative modes, the role of nodal points or concentration and distribution points become essential. In a world where the logistics policy of production and distribution sectors develop, such nodal points become important points of industrial strategies as well as important point of land use planning of regional authorities.

- From a logistic point of view they are privileged locations for warehouse and inventory
- For modes operators they are focal points for collection and distribution : rail transport, intermodal transport, maritime transport, air transport are competitive against road when a minimum volume of traffic can be transported from an origin to a destination
- For local authorities they are complementary investments to infrastructure links in order to obtain a better use of the infrastructures : for some cities nodal points at regional level or metropolitan level will be entry points to urban transport when more stringent conditions might be imposed (regulation of transport problem, urban logistics).

In other words regional space is a space where the transport organisation takes place for long distance haul with

- intermodal centres for intermodal transport
- ports of short sea shipping on inland waterways

airports served with public services on same time HST lines

- railways stations for HST networks or intercity networks.

For freight transport the regional space must often be considered as a whole because of the necessity to concentrate a sufficient volume of traffic for frequent freight services : the European network is more an interregional network.

For passenger transport the urban or suburban spaces are often the relevant ones to launch a high quality intermodal service, with HST or air transport.

2.4.3. A multilevel governance

The bridging of transport and spatial policies is obviously a long term objective which calls for a new definition of long term decision process. This process takes now place in a context where different institutional actors must cooperate, at national, European and regional or local level. Consultation of associations and groups of citizens is also required which means more transparency and democracy in the process. Therefore it is important to define new tools according to these objectives and context.

This means in particular the definition of relevant criteria such as accessibility criteria mentioned before which must be integrated in the prioritisation of the projects : so for CBA techniques have been privileged for the choice of priorities. These techniques are able to take into account external efforts through monetarisation. But this techniques are not well adapted to accessibility criteria ; multicriteria techniques can then be proposed but the problem of weighting the criteria will always lead to the setting up of an adequate dialogue process.

From the past experience several aspects must then be stressed so that each of the actors can better understand their role in the implementation of a more comprehensive policy :

- Importance of the definition of a common scenario of reference from which different policy options can be derived : this will concern socio-economic environment and transport projection associated to it
- A robust segmentation of the transport demand including a distinction between local, national, international and intercontinental traffics
- An analysis of the performances of the transport operating system, in complement of the analysis of the quality and capacity of existing infrastructures.
- A specific description of intermodal transport chain including the location and performances of the nodal points so that terminal leg of transport can be associated to long haul transport.
- And finally a good visualisation of the results with GIS tools so that dialogue and consensus can be obtained on solid, convincing grounds.

Such elements structure a database to support decision process which must become a continuous process with regular evaluation of the progress, which in other words means the implementation of a monitoring system.

Chapter III Existing indicators

This chapter provides a brief review on existing indicators for transport networks and services. It commences with the supply side of transport infrastructure and services. Then, indicators for the actual use of transport infrastructure and services are summarised. After that, the concept of accessibility as baseline for territorial indicators is introduced; relevant accessibility models and their indicators are presented. Finally, a brief section is devoted to innovative mapping approaches. The purpose of the chapter is to serve as kind of shopping list for the next phase in ESPON 1.2.1, namely the demonstration of existing indicators to the territory of EU15 plus the candidate countries plus Norway, Liechtenstein and Switzerland.

3.1 Supply of transport infrastructure and services

This section gives a very brief overview which kind of supply indicators are used in relevant documents and studies. Indicator groups in this section include the transport infrastructure supply as such, i.e. transport infrastructure endowment, capacity of infrastructure, indicators of transport services and indicators of network vulnerability. Indicators will be mainly presented in list form.

3.1.1 Indicators of transport infrastructure supply

Transport infrastructure supply indicators can be grouped in two basic categories. Endowment indicators consider the transport infrastructure in an area expressed by such measures as total length of motorways or number of railway stations. Morphological indicators describe features of modal networks and are mainly derived from graph theory or fractal theory. Table 3.1 gives an overview on these types of indicators.

Table 3.1 Existing indicators of transport infrastructure supply

Indicator type	***Sample indicator***
Transport endowment	Length/density of roads by road category Length/density of railways by railway category Number of ports Number of airports
Network distance	Ratio euclidean v. network distance (length, cost, time) Indicator of circuitry - curve of edges - detour of path
Graph theory	Degree of vertex Saturation (planar graph saturated) Vulnerability of graph Edge connected, K-connected
Fractal theory	Fractal dimension of network Fractal dimension of subgraph

3.1.2 Indicators of transport infrastructure capacity

Transport infrastructure capacity indicators can be grouped in two basic types, one describing capacities of links, the other capacities of terminals. Because there are many definitions of capacity which are not independent from the kind of service supplied, Table 3.2 can give only broad classes of capacity indicators.

Table 3.2 Existing indicators of transport infrastructure capacity

Indicator type	***Sample indicator***
Link capacity	Capacity of road Capacity of railway track Capacity of ferry link
Node capacity	Capacity of road nodes (intersections, tollbooth) Capacity of airport by category Capacity of port by category Capacity of intermodal terminals

3.1.3 Indicators of transport services

Existing indicators of transport services can be grouped in five basic indicator types: basic supply of nodes reflect the level of services available in nodes of rail, air and waterway networks; travel time and travel cost indicators cover the disutility for the user of a certain link or a certain route and can be further differentiated (e.g. by type of vehicle and issues such as statutory rest periods of drivers, safety or traffic regulations in form of aircraft grounding or traffic banning during night time.

Table 3.3 Existing indicators of transport services

Indicator type	***Sample indicator***
Basic supply	Number of departing/arriving trains by category and destination Number of departing/arriving flights by destination Number of departing/arriving ferries by destination Number of passenger cars Number of public transport vehicles by type Number of goods vehicles by type
Travel time	Link travel time by transport mode or multimodal Origin-destination travel time by transport mode or multimodal
Travel cost	Link travel cost by transport mode or multimodal Origin-destination travel cost by transport mode or multimodal and type of traveller

3.1.4 Indicators of network vulnerability

The natural hazards Europe has faced during the last couple of years and in particular during this summer and the demolishing of transport infrastructure and services has given attention to indicators describing the exposure of transport infrastructure to potential damage. However, little more than nothing exists so far in this respect (see Table 3.4).

Table 3.4 Existing indicators of transport vulnerabilitys

Indicator type	***Sample indicator***
Network vulnerability	Geographic structural vulnerability of corridors Climatic vulnerability of corridors

3.2 Use of transport networks and services

This section provides a brief overview which kind of indicators for the actual use of transport networks and services are used in relevant documents and studies. A distinction is made between traffic indicators showing volumes on links or in nodes and flow indicators which always include origin and destination of the flows.

3.2.1 Traffic volume indicators

The actual use of the transport infrastructure networks and services is captured by traffic indicators. There are five types, transport quantities, traffic on links and traffic in terminals, and also indicators describing the environmental effects of traffic in terms of consumption of natural resources and pollution as well as indicators describing transport safety.

Table 3.5 Existing traffic volume indicators

Indicator type	***Sample indicator***
Transport quantities	km per person per mode by purpose km per ton by goods type per mode modal split (passenger and freight)
Link traffic	Traffic on roads by vehicle type Number of trains and passengers on rail links Number of passengers and freight, cars and lorries on ferries
Terminal traffic	Traffic volume (passenger and freight) of airports Traffic volume (passenger and freight) of ports Traffic volume (freight) in intermodal terminals
Energy consumption and pollution	Consumption of mineral oil products by link and by region Emission of green house gases by link and by region Emission by pollutant by link and by region
Transport safety	Number of persons killed by mode Number of persons injured by mode

3.2.2 Traffic flow indicators

Traffic flow indicators are different from traffic volume indicators as they always include origin and destination, i.e. the relationship between two different points in space (see Table 3.6).

Table 3.6 Existing traffic flow indicators

Indicator type	***Sample indicator***
Traffic flow	Passenger flows by user type, trip purpose Trade/goods flows by type of good

3.3 Accessibility indicators

In the context of spatial development, the quality of transport infrastructure in terms of capacity, connectivity, travel speeds etc. determines the quality of locations relative to other locations, i.e. the competitive advantage of locations which is usually measured as accessibility. Investment in transport infrastructure leads to changing locational qualities and may induce changes in spatial development patterns.

There are numerous definitions and concepts of accessibility. A general definition is that "accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where 'area' may be a region, a city or a corridor" (Wegener et al., 2002). Accessibility indicators can differ in complexity. More complex accessibility indicators take account of the connectivity of transport networks by distinguishing between the network itself and the activities or opportunities that can be reached by it. These indicators always include in their formulation a spatial impedance term that describes the ease of reaching other such destinations of interest. Impedance can be measured in terms of travel time, cost or inconvenience.

This sub-chapter first presents generic accessibility concepts and dimensions of accessibility. Then, new accessibility models at the regional scale are briefly presented. Finally, pan-European accessibility models are reviewed in terms of their dimensions.

3.3.1 Accessibility concepts

In this section, accessibility indicators are addressed in which, in more general terms, accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them:

where A_i is the accessibility of area i, W_j is the activity W to be reached in area j, and c_{ij} is the generalised cost of reaching area j from area i. The functions g(W_{ij}) and f(c_{ij}) are called *activity functions* and *impedance functions*, respectively. They are associated multiplicatively, i.e. are weights to each other. That is, both are necessary elements of accessibility. A_i is the total of the activities reachable at j weighted by the ease of getting from i to j.

These more complex accessibility indictors can be classified by their specification of the destination and the impedance functions (Schürmann et al., 1997, Wegener et al, 2002; see Table 1):

- Travel cost indicators measure the accumulated or average travel cost to a pre-defined set of destinations, for instance, the average travel time to all cities with more than 500,000 inhabitants.

- Daily accessibility is based on the notion of a fixed budget for travel in which a destination has to be reached to be of interest. The indicator is derived from the example of a business traveller who wishes to travel to a certain place in order to conduct business there and who wants to be back home in the evening (Törnqvist, 1970). Maximum travel times of between three and five hours one-way are commonly used for this indicator type.

- Potential accessibility is based on the assumption that the attraction of a destination increases with size, and declines with distance, travel time or cost. Destination size is usually represented by population or economic indicators such as GDP or income.

Table 3.7. Generic accessibility indicators.

Type of accessibility	Activity function $g(W_j)$	Impedance function $f(c_{ij})$
Travel cost Travel cost to a set of activities	$W_j \left\| \begin{array}{l} 1 \text{ if } W_j \geq W_{\min} \\ 0 \text{ if } W_j < W_{\min} \end{array} \right.$	c_{ij}
Daily accessibility Activities in a given travel time	W_j	$1 \text{ if } c_{ij} \leq c_{\max}$ $0 \text{ if } c_{ij} > c_{\max}$
Potential Activities weighted by a function of travel cost	W_j^a	$\exp(-b\, c_{ij})$

Each of the different accessibility types can be seen to have their own advantages and disadvantages. Travel time indicators and daily accessibility indicators are easy to understand and to communicate though they generally lack a theoretical foundation. Potential accessibility is founded on sound behavioural principles but contain parameters that need to be calibrated and their values cannot be expressed in familiar units.

From the three basic accessibility indicators, an almost unlimited variety of derivative indicators can be developed (cf. Ruppert, 1975), the most important ones being multi-modal, inter-modal and interoperable accessibility. In all three cases the equations presented above remain valid; what changes is the way in which transport costs are calculated.

Modal accessibility indicators are usually presented separately in order to demonstrate differences between modes. Or, they may be integrated into one indicator expressing the combined effect of alternative modes for a location. There are essentially two methods of integration. One is to select the fastest mode to each destination, which in general will be air for distant destinations and road or rail for shorter distances, and to ignore the remaining modes. Another way is to calculate an aggregate accessibility measure combining the information contained in the modal accessibility indicators by a 'composite' generalised travel cost. This is superior to average travel costs across modes because it makes sure that the removal of a mode with higher costs does not result in a – false – reduction in aggregate travel cost.

Inter-modal accessibility indicators take account of inter-modal trips involving two or more modes. Inter-modal accessibility indicators are potentially most relevant for logistic chains in freight traffic with different possible combinations of freight modes and terminals such as rail freight with feeder transport by lorry at either end. Inter-modal accessibility indicators in passenger travel involve mode combinations such as rail-and-fly or car access to railways.

Dimensions of accessibility indicators

Accessibility indicators may be sensitive to the following dimensions: origins, destinations, impedance, constraints, barriers, types of transport, modes, spatial scale, equity and dynamics (Wegener et al., 2000; 2002).

- *Origins:* Accessibility indicators may be calculated from the point of view of different population groups such as social or age groups, different occupations such as business travellers or tourists, or different economic actors such as industries or firms.
- *Destinations*: Accessibility indicators may measure the location of an area with respect to opportunities, activities and assets such as population, economic activities, universities or tourist attractions. The activity function may be rectangular (all activities beyond a certain size), linear (of size) or non-linear (to express agglomeration effects).
- *Spatial impedance:* The spatial impedance term may be a function of one or more attributes of the links between areas such as distance (Euclidean or network distance), travel time, travel cost, convenience, reliability or safety. The impedance function applied may be linear (mean impedance), rectangular (all destinations within a given impedance) or non-linear (e.g. negative exponential).
- *Constraints:* The use of the links between areas may be constrained by regulations (speed limits, access restrictions for certain vehicle types or maximum driving hours) or by capacity constraints (road gradients or congestion).
- *Barriers:* In addition to spatial impedance the non-spatial, e.g. political, economic, legal, cultural or linguistic barriers between areas or non-spatial linkages between areas such as complementary industrial composition may also be considered

- *Types of transport:* Only personal travel or goods transport, or both, may be considered
- *Modes:* Accessibility indicators may be calculated for road, rail, inland waterways or air. Multi-modal accessibility indicators combine several modal accessibility indicators. Inter-modal accessibility indicators include trips by more than one mode.
- *Spatial Scale:* Accessibility indicators at the continental, transnational or regional scale may require data of different spatial resolution both with respect to area size and network representation, intra-area access and intra-node terminal and transfer time.
- *Equity:* Accessibility indicators may be calculated for specific groups of areas in order to identify inequalities in accessibility between rich and poor, central and peripheral, urban and rural, nodal and interstitial areas.
- *Dynamics:* Accessibility indicators may be calculated for different points in time in order to show changes in accessibility induced by transport infrastructure investments or other transport policies, including their impacts.

3.3.2 New regional accessibility models

Since the detailed review of accessibility models done by the Working Group 'Geographical Position' of the Study Programme on European Spatial Planning – SPESP (Mathis, 2000; Wegener et al., 2000, 2002) some development of accessibility models has taken place. This section presents those new accessibility models that do cover only a region. The notion of region is very broad comprising one or more than one NUTS-2 region, countries or INTERREG IIC/IIIB regions. New accessibility models covering the whole of Europe will be presented as part of the next section.

Menerault and Stransky (1999) proposed an approach of long distance accessibility based on intermodal connections between air and high speed rail. They compared air only, rail only and air-rail journeys departing from Lille to a set of destinations in France. They showed that the high speed rail connection at the airport of Charles-de-Gaulle gives to the Lille passengers an improved accessibility, with an increase of the supply for most of the directly air connected cities, but also with a set of new possible destinations. The contribution demonstrates the new opportunities of high-speed rail and air connections in terms of transport service. It invites to question those indicators that are based only on infrastructure. For a city of a high level in the European hierarchy like Lille, what is the most important in terms of accessibility? Is it the possession of an international airport or is it the availability of a high-speed rail access to a major European hub? This example shows that the combination of high speed modes has top be considered in the study of accessibility at the European scale.

In a background study for the spatial development perspective VASAB of the Baltic Sea Region Spiekermann developed a disaggregate accessibility model for that INTERREG IIC area (Hanell et al., 2000). Daily accessibility indicators for road, rail and air were calculated for raster cells of 10x10 km. The indicators were presented in three-dimensional accessibility surfaces showing the number of inhabitants that can be reached within five hours door-to-door travel time. Of relevance here are the spatial detail and the option to display difference maps of accessibility between transport modes or between different years.

L'Hostis and Decoupigny (2001) developed an assessment of the quality of service of public transport for supporting spatial planning principles at a regional scale. From a set of cities the authors analysed the relations corresponding to spatial patterns of the external relations, the hierarchical network, or city network. The assessment was done through analysing the possibility of doing a return journey between cities for complete working-day corresponding to a daily mobility pattern. The quality of the transport service is obtained if a "quick train at the right moment" is available in the morning, and after 9 hours spent in the destination city. This analysis of the daily accessibility indicator type shows the lack in the quality of service corresponding to the intercity relations to be developed if one wishes to support the spatial cohesion principles of hierarchical and city network.

Spiekermann et al. developed a NUTS-5 accessibility model for fourteen urban agglomerations in north-western Europe for the GEMACA II project (Spiekermann et al., 2001). The indicator used was of the potential type and was calculated as European-wide road, rail and air accessibility of the municipalities. Results were presented in diagrams and maps, the latter showing accessibility of municipalities of the fourteen agglomerations standardised to the European average. The spatial detail led to the conclusion that accessibility within an urban region can be very different and depends on the location of municipalities with respect to the next nodes of high-level transport infrastructure, mainly with respect to high-speed rail stations and airports.

Geurs and Ritsema van Eck (2001) developed an accessibility model for the Netherlands for measuring job accessibility. A vast range of indicators were tested, including daily accessibility type indicators adjusted for commuters (45 and 60 minutes maximum travel time), potential type indicators as well as balancing factor or utility-based measures. Indicator values were calculated for Dutch municipalities, i.e. NUTS-5 regions. Transport modes were car and public transport. The model was used to analyse the effect of a set of land-use transport scenarios. Results were presented in maps showing the outcome of the different indicators and scenarios.

Luis (2002) applied temporal accessibility to the case of the Canary Islands archipelagos, and provided useful indications on two interesting directions with respect to the transport network issues. Firstly the accessibility indicators were applied to maritime passenger transport which belongs to the transport modes to be treated in ESPON 1.2.1. Secondly the method developed envisages an accessibility measure that allows assessing the service of transport. The measure is directly related to mobility needs through a door to door approach and is based on time table information for ferries. The indicator of time available at destination, i.e. an indicator of the daily accessibility type, is used to assess the territorial cohesion of the archipelago.

3.3.3 Accessibility models for Europe

Over the last decades a vast number of accessibility studies addressing European core-periphery issues have been published. This chapter will briefly review the most important European accessibility models; the selection follows that in a number of more detailed reviews (Bruinsma and Rietveld, 1998; Wegener et al., 2000; 2002). Because the focus of the ESPON 2006 Programme is on territorial indicators for Europe, this section tries to give an overview on all European-wide accessibility models of the last decade and not only on the most recent (as it was done for the regional models in the previous section).

Most accessibility studies have a regional or national focus, but often not a European dimension. However, there are a growing number of accessibility models that address European-wide accessibility and thus European peripherality. This section will briefly introduce European accessibility models developed in the last two decades and will try to classify and compare the accessibility indicators used by applying the dimensions of accessibility presented in the previous chapter. The order in which the models are presented is strictly chronological.

Keeble et al. (1982, 1988) were commissioned by DGXVI of the European Commission to analyse economic core-peripherality differences between the regions of the Community and to investigate whether any differences can be explained by relative location. For this purpose, they developed a gravity potential model with regional GDP as destination activity and road distance costs as impedance. The results are expressed as an Economic Potential Index and are presented in map form as contour lines.

The group of Törnqvist presented a more recent application of his method of daily accessibility developed in the early 1970s (Cederlund et al., 1991; Erlandsson and Törnqvist, 1993). The indicator is expressed in million inhabitants that can be reached from a city by a return trip during a work day with four hours minimum stay using the fastest available mode (outbound accessibility) or in million inhabitants that can reach a city by such a return trip (inbound accessibility). The important differentiation between in- and outbound accessibility is possible due to the use of time table information. Indicators are presented in numbers and map form for more than 100 important cities in Europe.

Grasland (1991, 1999) developed accessibility indicators based on geographical or Euclidean distance between areas as spatial impedance. The spatial reference system is a grid of cells of 1° latitude and longitude. One indicator expresses the mean Euclidean distance to the population of Europe. Another uses the Euclidean distance in a potential analysis based on the Gaussian neighbourhood function. The indicator was used to illustrate the spatial integration taking place through the opening of the borders to eastern Europe. The indicator is expressed as population potential and presented in map form as contour lines.

The *Bundesforschungsanstalt für Landeskunde und Raumordnung* (Lutter et al., 1992, 1993) in a study for DG Regio of the European Commission calculated the accessibility of NUTS-3 regions in the then twelve Member States of the European Community as average travel time by inter-modal transport (road, rail, air) to 194 economic centres in Europe. In the same study they also used other destinations such as the next three agglomerations, the next high-speed train stop or the next airport. In addition, they calculated a daily accessibility indicator as the number of people that can be reached in three hours using the fastest connection. Modes considered included road, rail and air with and without planned infrastructure investments (new motorways, high-speed rail lines and more frequent flight connections).

Bruinsma and Rietveld (1993) calculated potential accessibility of European cities with respect to population for road, rail, air and fastest mode. Results are presented in tables and map form in which the sizes of the circles indicate not population but accessibility of cities standardised to the maximum accessibility value. The resulting map for cities closely resembles the contour maps by Keeble et al and so demonstrates the spatial correlation between economic and population centres. Important is also the consideration of non-physical aspects of borders and their effect on accessibility.

MCRIT (1994; 1999) developed the ICON indicator, which evaluates the quality of access to the nearest nodes of long-distance transport networks weighted by importance and level of services. The indicator is a sophisticated transport infrastructure and service endowment indicator which calls attention to the fact that many accessibility indicators ignore the quality of local access to long-distance networks. The concept has been used in a number of regional and European-wide studies (Europe 2000, Europe 2000+ etc.) and is in process to be applied by the European Investment Bank to evaluate the cohesion interest of transport infrastructure projects The ICON indicator may be presented in maps which show the indicator values for small raster cells.

Spiekermann and Wegener developed three-dimensional surfaces of daily and potential rail accessibility for Europe using raster-based GIS technology (Spiekermann and Wegener, 1994a; 1996; Vickerman et al., 1999), road and air accessibility were added later (Schürmann et al., 1997; Fürst et al., 2000). The quasi-homogenous accessibility surface was achieved by sub-dividing Europe into some 70,000 square raster cells of 10 km width and calculating accessibility indicators for each raster cell with respect to all other raster cells. The population of raster cells was estimated by allocating the population of NUTS-3 regions to raster cells with the help of a hypothetical negative-exponential gradient of population density around population centres. Access travel time from each raster cell to the nearest network node was approximated using an average travel speed of 30 km/h.

In the UTS (Union Territorial Strategies) study, Chatelus and Ulied (1995) developed several accessibility indicators for the evaluation of trans-European networks at the level of NUTS-2 regions in the EU plus Norway. One of them, the FreR(M) indicator, measured the average cost to reach a market area of a certain population size by lorry. The impedance term is generalised road transport cost including the cost of the driver's time, the cost per kilometre and a fixed cost component. The CON(T) indicator accumulated population of NUTS-2 regions of EUR15 plus Norway and Switzerland reachable within a maximum travel time of three hours by any combination of car, rail and air, with transfer times between modes explicitly considered. The CON(T) index was used to assess transport infrastructure scenarios with respect to the criteria competitiveness, cohesion and sustainability. The FreR(T) index, a freight accessibility indicator expressing the size of the market that can be reached in a certain travel time accumulates the population that can be reached in one, two or three days by the fastest connection using road, rail or combined traffic with driving time restrictions for lorry drivers observed.

Gutiérrez et al. (1996) and Gutiérrez and Urbano (1996) calculated average travel time by road and rail from about 4,000 nodes of a multi-modal European transport network to 94 agglomerations with a population of more than 300,000 with and without planned infrastructure improvements. Road travel times included road and car ferry travel times modified by a link-type specific coefficient and a penalty for crossing nodes representing congested population centres. Rail travel times included time table travel time plus road access time and penalties for changes between road and rail (60 minutes), rail and ferry (180 minutes) and the change of rail gauge between Spain and France (30 minutes).

In studies for the Highlands and Islands European Partnership Programme and for DG Regio of the European Commission, Copus (1997, 1999) developed "peripherality indicators" for NUTS-2 and NUTS-3 regions based on road-based potential measures of the Keeble type. The model takes account of different average speeds for different classes of road, realistic ferry crossing and check-in times, EU border crossing delays and statutory drivers' rest breaks. Accessibility is presented as a peripherality index derived as the inverse standardised to the interval between zero (most central) and one hundred (most peripheral).

In a report of the Study Programme on European Spatial Planning for DG REGIO, Wegener et al. (2000; 2002) proposed reference indicators describing the geographical position of European NUTS 3 regions. Besides geographical, physical and cultural indicators, three accessibility indicators were proposed. The first two measure accessibility by road and rail to population, the last one, accessibility by air, to economic activity (expressed by gross domestic product, or GDP). Accessibility to population is seen as an indicator for the size of market areas for suppliers of goods and services; accessibility to GDP as an indicator of the size of market areas for suppliers of high-level business services. Accessibility is presented as index in which the average European accessibility serves as a reference.

Mathis (2000) developed accessibility indicators for Europe based on road travel times by car and lorry. The model is capable to include European or national regulations in form of constraints, example are statutory rest periods for lorry drivers and banning of lorry traffic during weekends in different countries. One of the advantages of the model is that not only travel times are calculated but that the model keeps record of which links are used by minimum-paths. The outcome of this is an indication of transport corridors facing large transport demand. Results are shown in maps displaying travel time from the selected origin as well as the number of itineraries using the same link.

Schürmann and Talaat (2000) produced a background report for the latest Cohesion Report of the European Commission (2001) in which an index of peripherality of the potential type was implemented in a geographical information system. Potential type indicators are calculated for passenger or freight transport by road using GDP, population or labour force as destination activity. The indicators are calculated for NUTS 3 regions and for the equivalent regions of the candidate countries as well as for Switzerland and Norway. Aggregation procedures for NUTS 2, 1 and 0 are offered by the system. The peripherality index is presented in two ways: either standardised on as the European average (as in Wegener et al., 2000) or to an interval between 0 and 100 (as in Copus, 1997, 1999).

Baradaran (2001) developed a pan-European accessibility model to analyse the impact of different indicator types and different forms of the impedance function on the output. He analysed two groups of travel cost indicator types and two groups of the potential type and linked those with four different impedance functions. Accessibility indicators have been calculated for more than 4,500 European cities with a population greater than 10,000. Results of the different model implementations are statistically analysed, in addition accessibility surface maps were constructed with GIS-based interpolation techniques.

Most recently, Spiekermann et al., (2002; Copus et al. (2002) developed a multi-modal accessibility indicator, i.e. an indicator that aggregates over modes and is thus capable of integrating the contributions of different transport modes to the degree of centrality or peripherality. The indicator is a logsum accessibility potential aggregating over road, rail and air. Multi-modal indicators are considered to have much more explanatory power with respect to regional economic performance than any accessibility indicator based on a single mode only (Fürst et al., 2000). The indicator is presented for NUTS 3 regions with a focus on the differentiation of peripheral areas. In addition, a national peripherality index has been developed for which only national destinations were considered.

The European accessibility models yield a wide range of approaches with respect to dimensions of accessibility. They differ in many respects, but there are also some commonalties:

- More than half of the models use a potential type indicator, the remaining use travel costs or daily accessibility indicators. A few models are able to calculate different types.
- Origins are usually NUTS-2 or NUTS-3 centroids, very few studies have a more detailed representation of space.
- The destination activities are usually population or GDP for the potential type models, and a pre-defined set of agglomerations for the travel cost indicators.
- Nearly all models use travel time as their impedance term, only a few apply travel costs.
- Models that consider freight transport use statutory drivers' rest breaks as constraints.
- Barriers are mainly in the form of border delays, only Keeble et al. use trade barriers.
- Nearly all models are based on personal travel, only a few consider freight transport.
- Half of the models consider one mode only, in most cases road. The other models have networks for different modes, however, only two use inter-modal travel times.

Table3.8. Dimensions of European accessibility indicators

Authors	**Generic Indicator type**	**Origins**	**Destinations**	**Impedance**	**Type of transport**	**Modes**	**Spatial scope**
Keeble et al. (1982; 1988)	Potential	NUTS 2 centroids	GDP in NUTS 2 and in non-EU countries	Road distance	-	Road	EU9 EU12
Cederlund et al. (1991) Erlandsson and Törnqvist, (1993)	Daily	European cities (about 100)	European cities (about 100)	Travel time	Personal	Fastest mode	pan-Europe
Grasland (1991; 1999)	Potential	1° raster cells	Population in 1° raster cells	Euclidian distance	-	-	pan-Europe
Lutter et al. (1992, 1993)	Travel cost Daily	NUTS 3 centroids	194 Centres next 3 agl. airports etc.	Travel time	Personal	Road rail air inter-modal	EU12
Bruinsma and Rietveld, 1993	Potential	European agglomerations (42)	Population in 42 European agglomerations	Travel time	Personal	Road rail air fastest	EU 15 plus 8 countries
MCRIT (1994; 1999)	Travel cost	Raster cells	Next nodes of long-distance networks	Travel time	Personal	Road rail air multimodel	pan-Europe
Spiekermann and Wegener (1994a, 1996)	Daily potential	10 km raster cells	Population in 10 km raster cells	Travel time	Personal	Road rail air multimodal	pan-Europe
Chatelus and Ulied (1995)	Travel cost Daily	NUTS2 centroids	Population in NUTS 2	Travel cost	Personal freight	Road rail air inter-modal	EU15, Norway, Switzerland
Gutierrez and Urbano (1995, 1996)	Travel cost	4000 nodes	94 agglomerations	Travel time	Personal	Road rail	EU12
Copus (1997, 1999)	Potential	NUTS2 / NUTS 3 centroids	GDP, population, workforce in NUTS 2/3	Travel time	Personal	Road	EU15, candidate countries, Norway, Switzerland
Wegener et al., (2000, 2002)	Potential	NUTS 3 centroids	Population, GDP in 10 km raster cells	Travel time	Personal	Road rail air	EU15
Mathis (2000)	Travel cost	Selected origins	Network nodes and NUTS 2	Travel time	Personal freight	Road	EU15
Schürmann and Talaat (2000)	Potential	NUTS 3 centroids	GDP, population, workforce in	Travel time	Personal freight	Road	EU15, candidate countries

			NUTS 3				
Baradaran (2001)	Travel cost potential	4500 European cities	Population in 4500 cities	Travel time	Personal	Road	pan-Europe
Spiekermann et al., (2002)	Potential	NUTS 3 centroids	Population in 10 km raster cells	Travel time	Personal	Multi-modal (road, rail, air logsum)	EU15

3.4 Map-based indicators

Existing indicators of transport infrastructure and services are either presented in tabular form, in diagrams or, mainly, in cartographic representations. Maps do show transport infrastructure, transport services, transport volumes and flows, and accessibility either for transport links, nodes or regions. Some maps do show quasi-continuous surfaces of indicators based on a raster representation of space (Spiekermann and Wegener, 1996; MCRIT, 1999).

In addition, there are some methodologies developed in cartography which produce maps that cannot be translated into indicator values. The purpose of those maps is to present a visual image of the relationship between transport and space:

- Time space maps offer a technique to visualise effects of different travel times. Time-space maps represent the time space. The scale is in temporal, not in spatial units. Short travel times between two points result in their presentation close together on the map; points separated by long travel times appear distant on the map. This change of the metric results in distortions of the map compared to physical maps. Network sections with low travel speed lead to an enlargement of that area on the map, sections with high travel speed lead to contractions and shrinking of that area on the time-space map. This kind of maps has been produced for different European countries and to demonstrate the 'space-eating' effect of the emerging high-speed rail network in Europe (Cauvin, 1994, Spiekermann and Wegener, 1994b).

- Chronocarts and costmaps go a step further in that they are able to show more than one transport mode in a map. Here, the location of nodes and cities will not be changed. The distortion due to different travel speeds or costs is introduced through the distortion of the surface in the third dimension. The length of an arc represents the travel time or cost on that link. If then, for instance, the travel time is slower than the physical distance, the arc is divided into two arcs of equal length, the middle point of the two arcs is pushed down until the length of the two arcs corresponds to the travel time. This results in a three-dimensional representation showing the nodes as hill tops and the arcs of the slower modes forming valleys. Chronocarts have been produced for different European countries and also to compare the emerging European high-speed rail network in Europe with other modes (L'Hostis, 1996).

3.5 Conclusions on existing indicators

The chapter has provided an overview on existing indicators describing transport infrastructure and services. Indicators do range from transport infrastructure and service supply via their use in form of traffic volume and flow indicators towards territorial indicators in form of accessibility indicators.

Existing indicators can roughly be classified into two groups:

- - Indicators derived from published statistics,
- - Indicators derived from modelling.
- The two indicator groups are very different with respect to data availability. Indicators derived from published statistics are in most cases not available at the regional level required in ESPON. Here, many indicators are obtainable only at the national level. On the other hand, indicators derived from modelling work haven been already or can easily be calculated for the desired NUTS 3 level or for links or nodes.

Any indicator presents just a simplified model of understanding and explaining reality; by definition, they just "indicate" certain aspects of the problem or the concept being studied while other aspects remain dark. Successful indicators, rather than trying to explain everything, have to be focused on key aspects, illuminating those aspects more relevant to the problem under scrutiny. Therefore, multiple indicators, as scientifically consistent and policy-meaningful as feasible, are needed to get useful insights.

To be policy-relevant, indicators have to be defined to measure the accomplishment of policy aims, and discriminate properly between different places and between different moments in time, in order to assess the potential impacts of a given policy.

The purpose of the study is one the one hand updating existing indicators and advancing in new indicators scientifically consistent and relevant to contemporary trends on transport, and on the other, gathering a policy-meaningful set of them, in the sense already mentioned. The conclusion for ESPON 1.2.1 is that it should be tried to take advantage of the variety of existing approaches and models and should try to fill indicator gaps in relevant fields. In addition, raster-based maps, time-space maps and chronocarts may be considered as a starting point to develop innovative cartographic methodologies in ESPON 1.2.1.

Chapter IV Proposed concepts and methods

The research questions of ESPON 1.2.1 cover issues related to the basic supply of transport infrastructure and services within the EU territory as well as territorial trends of transport infrastructure network and services. Transport infrastructure comprises the transport modes of road, rail, air and waterways, but also issues of inter-modality. In particular, the following points should be considered in the project:

- Identification, gathering of existing and proposition of territorial indicators and data and map-making methods to measure and display the basic supply of transport infrastructures and services as well as the trends and impacts of the development of transport infrastructure network and services. Compilation of national studies with European focus should be undertaken;
- The most important features of the present infrastructure networks with regard to territorial issues, i.e. the location and capacity of primary and secondary networks, the spatial patterns of access points, the flows between the access points identified (usually in an hierarchical order) and the number of users (types of users), which have access in real terms (different quality) to the networks;
- Specific typologies and territorial patterns in the transport infrastructure networks and services, referring to in particular the typologies used in the ongoing ESPON project 1.1.1 on polycentrism and to typologies of regions in other ESPON projects;
- The most relevant transport services of general interests, referring to migration and regional development potential, which influence the development of territories and regions lagging behind as well as territories and regions with a peripheral location or specific features (structurally weak areas, islands and mountain areas);
- The role of services of general interest as vectors for territorial cohesion: constitution of trans-European networks of services of general interest (in particular, in rural areas).
- The different kinds of complementarity and exchange processes (level of multi-modality) that exist between different kinds of infrastructure in different parts of Europe in support of sustainable transport.
- The importance of access to transport networks and services as a location parameter for investments and the economic development of cities and regions
- The correlation between transport infrastructure trends and a polycentric development model, including identification of an operational benchmarking system that could be applicable with regard to the data and indicators available;

- A further operationalisation and territorial diversification of the policy aims and options adopted in the ESDP, including an adaptation to the territorial diversities within an enlarged EU.

Consequently, the study will have a strategic and territorial approach. Therefore, it relays in data and knowledge to be obtained from studies and researches mostly developed in the transport field. More than deepening transport specialised questions, the aim is integrating in them the still missing territorial dimension.

The first section of this chapter will present the basic concept of the project with respect to indicators on basic supply of transport infrastructure and services. The second section advances then as working hypothesis a number of indicators and suggests methodologies to calculate them. Depending on the final data availability, the production of some of them will not be feasible. The third section develops an idea how to integrate the different indicators that will be generated and how to draw territorial typologies from this integrated data set.

4.1 Concept for Indicator Development and Implementation

The concept developed for ESPON 1.2.1 is a combination of state-of-the-art and newly developed methodologies with the objective to generate an indicator database describing different aspect of transport infrastructure and services in Europe and its regions. The proposed concept will result in tangible and innovative results. The concept for the development and implementation of indicators consists of five steps which correspond to five different work packages. Figure 4.1 shows the relationship between the five main components of the concept; afterwards, the contents of the five work packages will be presented.

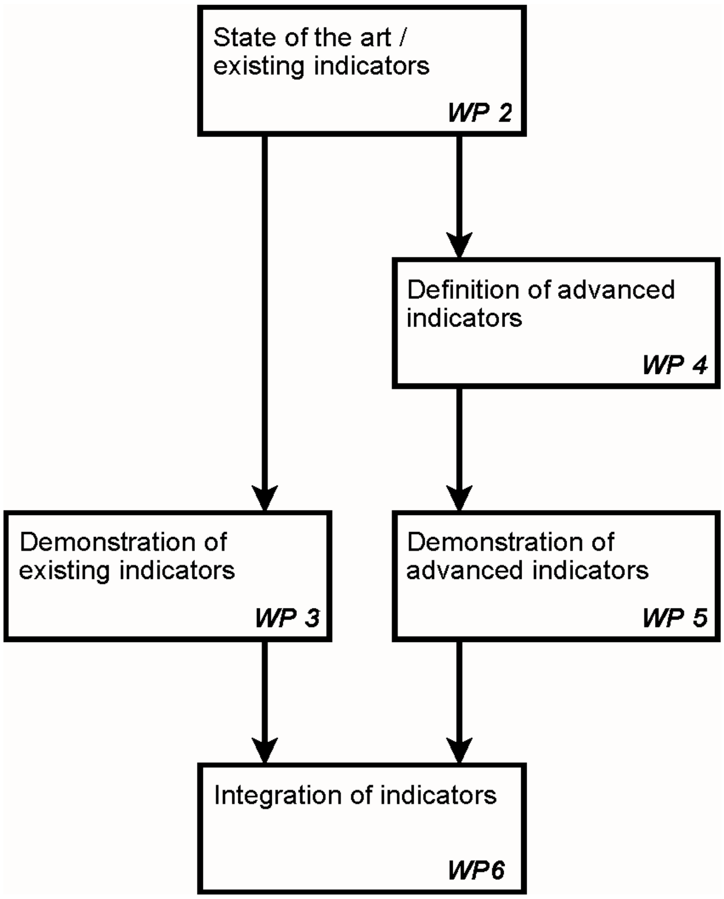

Figure 4.1 Concept for indicator development and implementation.

State of the art / existing indicators (WP 2)

The base line of the project is a review of existing indicators for measuring the supply of transport infrastructure and services and accessibility. The main results of this review have been presented in the previous chapter of this report. The review was done by analysing previous studies and existing databases. The identification and gathering of existing indicators was guided by the reports for the Working Group 'Geographical Position' of the Study Programme on European Spatial Planning (SPESP) in which team members played a prominent role (Mathis, 2000; Wegener et al., 2000; 2002). Important indicators and models developed since then have been included.

Demonstration of existing indicators (WP 3)

It has been shown in the previous chapter that the geographical extent and spatial detail of the existing indicator is in most cases not appropriate for the objectives of the ESPON programme. Therefore, selected indicators of the existing indicators reviewed before will be demonstrated for the territory of the European Union, the twelve candidate countries plus Norway, Liechtenstein and Switzerland. This will be done by gathering empirical data and modifying existing models available at project partners' institutes for indicators on supply and use of transport infrastructure and services and accessibility indicators. The objective is to have the existing indicators demonstrated for NUTS 3 regions and equivalent regions outside the EU or - depending on the indicator type - for a detailed set of nodes or links. However, for many empirical indicators it is probably not possible to collect data at that spatial detail. In such cases, the objective is to be as detailed as possible.

Definition of advanced indicators (WP 4)

The existing indicators do answer the research questions only to a certain degree. Therefore, based on an analysis of the existing indicators the possibilities to develop new indicators showing the interrelationships between the supply, trends and impacts of transport infrastructure networks and services and territorial features, such as the degree of polycentrism, accessibility to different types of regions and territories, areas lagging behind, inter- and multimodality and missing links for improving sustainable European passenger transport and the territorial integration of the candidate countries will be explored. Appropriate indicators will be defined.

Implementation of advanced indicators (WP 5)

The indicators developed before will be demonstrated. The philosophy to do this is to make use of the plurality of the different approaches and tools available in the project consortium, i.e. at the research institutes of project partners and sub-contractors. Some of the indicators will be very comprehensive, e.g. multimodal and intermodal accessibility indicators, some might be very specific, e.g. addressing coastal shipping, some of the indicators will be calculated for NUTS 3 and equivalent regions, some of the indicators can be presented in innovative graphical form only (e.g. chronocartes, time-space maps). Most of the indicators will be calculated for pan-Europe, however, there will be some indicators that can be demonstrated for specific areas only.

Integration of indicators (WP 6)

Finally, the existing and newly developed indicators will be collected in an integrated and harmonised database. Analysis and mapping tools to be developed will allow the comparative processing and the comparison of different indicators in numerical or cartographic form, the combination of indicators to new indicators, advanced spatial analysis and the spatial aggregation of indicators to the level of NUTS 2, 1 or 0. The integration step will provide the base for the development of typologies of European regions revealing risks and potentials and will serve as platform for data exchange with other parts of the ESPON 2006 programme.

4.2 Preliminary Indicators and Methods

There is a spontaneous tendency in the transport market to facilitate the access to most interesting destinations so to reduce generalised transport costs, those with higher trip demand, and this encourages more social and economic relations increasing the attractivity of places. This well-known feedback may result in short-term economic growth but may also increase environmental impacts in more dense corridors while large zones of the territory remain poorly accessible.

On the other hand, transport networks have also been part of national policies aiming to control or give structure or achieve a more balanced territory, for instance facilitating the access to selected cities or corridors independently of the interest they have in economic terms.

In conclusion, multiple and complementary indicators based on different concepts of accessibility are needed to highlight these questions at European scale. They should be able to provide a territorial reading as accurate as possible of the transport system, which is characterised by the quality of services provided to the different demand segments.

This section advances as working hypothesis a number of indicators and suggests methodologies to calculate them. Depending on the final data availability, the production of some of them will not be feasible. In addition, the definition of new and advanced indicators is subject of Work Package 4 which will commence only after the delivery of this report. A final list of indicators will be established in the 2nd Interim Report.

All indicators will be demonstrated for the European Union, the candidate countries plus Norway, Liechtenstein and Switzerland, if possible for NUTS-3 regions and in cartographic form. Indicators will be calculated for two scenarios, the current situation (approximately year 2000) and a reference scenario (completion of Trans-European transport networks, implementation of current policies). Scenarios will be defined based on available research studies by DG TREN of the European Commission.

In line with the categories developed in Chapter 3, the list of indicators includes indicators of the following groups:

- indicators describing the supply of transport networks and services,
- indicators describing the use of transport networks and services,
- accessibility indicators.

As said before, the definition of advanced indicators is a creative and innovative element of the project. Therefore, it is difficult to precisely define all indicators at this stage. However, it is possible to outline several indicator categories that will probably be included in the final list of indicators. The following preliminary description of the potential indicators does not distinguish between existing and new indicators; the purpose is to give an idea of the final outcome in terms of indicators. It should also be said that this is not a closed list but open to new proposals and amendment.

4.2.1 Accessibility potential as SPESP reference indicator concepts

Accessibility potential has been proposed by the Working Group "Geographical Position" of the Study Programme on European Spatial Planning – SPESP as reference indicator concept (Wegener et al., 2000). Accessibility potential is one of the most common and most extensively tested accessibility indicators. Three kinds of potential accessibility indicators were suggested. The first two measure accessibility to population by road and rail, the third accessibility to economic activity (expressed by gross domestic product, or GDP). Accessibility to population is seen as an indicator for the size of market areas for suppliers of goods and services; accessibility to GDP an indicator of the size of market areas for suppliers of high-level business services. In SPESP, the three indicators have been demonstrated for NUTS 3 regions of the European Union.

The SPESP reference indicators will be used in ESPON 1.2.1 as a starting point. The accessibility potential indicators will be used and developed as follows:

- The three SPESP reference indicators will be demonstrated for all European NUTS 3 and equivalent regions.
- The SPESP modal accessibility indicators will be developed to a multimodal accessibility indicator by testing ways of aggregation such as fastest mode and logsum aggregation.

- The SPESP modal accessibility indicators will be further developed to an intermodal accessibility indicator allowing for change of transport mode during a journey.

Results will be presented in numerical and cartographic form for NUTS 3 regions.

4.2.2 Transport infrastructure endowment

Until now, in European studies accessibility indicators have been very often focused on transport infrastructure measurements. The indicators most frequently used are "density of infrastructure" (km of motorways or motorways per surface or number of inhabitants) or "connectivity to transport terminals" (generalised cost to get motorways entrances, railways stations etc.). These indicators are able to capture the capacity of the infrastructure independently from the services actually provided by transport carriers and their quality, and the utility they provide to fulfil the development opportunities of the region.

The basic data needed to calculate this type of indicators are multimodal transport networks at European level, precise enough in terms of intermodal connections and location of transport terminals, with information concerning infrastructural characteristics.

Preparatory work includes update of databases concerning transport terminals and links based on European transport sources (DG TREN Pocket Book, Eurostat, Transport Associations, United Nations) and update of databases with respect to transport infrastructure projects and network connectivities in main terminals and large cities.

The preliminary list of proposed indicators includes

- Length/density of roads by road category
- Length/density of railways by railway category
- Number of ports
- Number of airports
- Generalised cost to motorway entrances by road
- Generalised cost to railway stations by road
- Generalised cost to airports by road
- Generalised cost to airports by rail
- Generalised cost to ports and logistic centres by road
- Generalised cost to ports and logistic centres by rail
- Combined cost to transport terminals based on ICON methodology (MCRIT, 1999).

For the density indicators, results will be presented for NUTS 2 and NUTS 3 regions in numerical form and in maps, and for the cost indicators represented as raster image (cells approximately 1 km x 1 km) and aggregated at NUTS 2 and NUTS 3 level as per cent of surface and population.

4.2.3 Network morphology

Morphological indicators describe features of modal networks and are mainly derived from graph theory or fractal theory.

Proposed indicators include

- Ratio euclidean v. network distance in terms of length, cost, time
- Curve of edges
- Altitude variation of arcs
- Detour of path
- Altitudes of path
- Degree of vertex
- Saturation (planar graph saturated)
- Type of mesh, regularity
- Vulnerability of graph
- Redundancy
- Pivots
- Edge connected, K-connected
- Fractal dimension of network
- Fractal dimension of subgraph
- Size of homogeneous subgraphs
- Number of fractal levels
- Self-similarity of levels

4.2.4 Traffic volumes and flows

The measure of volumes and flows in and out from a given place to all others already is an indicator of the actual accessibility, not related to the transport system by itself but to the integration of a region in a larger economic area. Actual traffic volumes and flows encapsulate other accessibility elements beyond the transport system such as cultural relations, language barriers, institutional cooperation...

However, flow matrices are not available as such in Europe and only in aggregate terms (work and leisure) for NUTS1. A metamodel able to generate flows between regions based on basic socio-economic data and urban structures may be useful to calculate this concept of accessibility based on changes not in the transport system but on the socio-economic and urban characteristics. For the purpose of the study, flow matrices generated by gravity type models will also be used.

A preliminary list of traffic volume and flow indicators includes:

- Km per person per mode by purpose
- Km per ton by goods type per mode
- Traffic on road links by vehicle type
- Number of trains and passengers on rail links
- Number of passengers and freight, cars and lorries on ferries
- Traffic volume (passenger and freight) of airports
- Traffic volume (passenger and freight) of ports
- Traffic volume (freight) in intermodal terminals
- Passenger flows by user type, trip purpose
- Goods flows by type of good
- Flows with origin and destination in different areas by modes

Indicators will be presented in numerical form and as maps showing traffic volumes and flows in terminals and on links, and, if available, between regions.

4.2.5 Travel times and cost

Travel time and travel cost indicator give a good impression of the effort to reach other places.

A preliminary list of travel time and cost indicators include:

- Link travel time by transport mode or multimodal
- Origin-destination travel times by transport mode or multimodal
- Link travel cost by transport mode or multimodal
- Origin-destination travel costs by transport mode or multimodal and type of traveller

Travel time and travel cost indicator will be presented in numerical form as well as in maps showing indicator values link by link or isochrones or isocosts for selected origins.

4.2.6 Service provision

Depending on the services provided by transport operators in a given moment, business travellers and tourists, and industries, may or not benefit from the existence of transport infrastructure. Only private transport by car or truck is independent from the services actually provided.

The indicators most frequently used are adapted to specific segments of transport demand, such as "number of efficient opportunities for daily round trips to key destinations" for business travellers, i.e. daily accessibility, or "market area achievable at a given time or cost" (in terms of total population, accumulated GDP...) for industries moving goods.

The data needed are basically schedules from transport operators. Being hardly available this data in practice, it is indispensable to generate a theoretical service database automatically, based on expert criteria and rules, and validate it against some known cases. This procedure may be useful to generate or propose potential services based on alternative scenarios (for transport and territorial policies, market regulations, etc.). Preparatory work for this includes review of existing passenger services for pilot transport operators (airlines, railways...) directly or throughout commercial timetables, review of passenger services between important cities, analysis of freight services.

Proposed indicators are based on the estimation, from main transport terminals, of the following services (frequency, commercial speed and average fare), but do also include the availability of vehicles:

- Long-distance bus services
- Long-distance truck services
- Regional and international passenger rail services
- Regional and international passenger air services
- Short-sea and transcontinental maritime freight services
- Number of passenger cars
- Number of public transport vehicles by type
- Number of goods vehicles

The main composite indicators based on available services will be as follows:

- *Daily accessibility*. Total population accessible from a given city in a given time allowing for business daily round trips by the most effective intermodal chain.
- *Commuter accessibility*. Total population accessible from a given city in a given time allowing for daily commuting by the most effective intermodal chain.
- *Market accessibility*. Total market area accessible from a given place at a given time

Indicators will be presented in numerical figures and in maps for NUTS 3 regions.

4.2.7 Quality of service

Actual traffics may reduce significantly the quality of the services provided by operators, especially when they are close to the infrastructural capacity, but also because of the probability of accidents, weather conditions, etc. Indicators such as "congestion levels", "excess of capacity", or "bottlenecks" are commonly used, or the difference in time and generalised cost, between ideal and actual quality of service.

Data related to actual traffics, or congestion for European transport networks, is partially available for certain modes and countries, and estimates are needed to get a homogeneous database useful for strategic studies. Based on this data, a transport forecast model able to assign origin and destination flows to transport multimodal networks would allow to produce these indicators for different scenarios. Flow matrices, the other type of data needed, are available at NUTS 1 level and below, not resulting from household surveys but calculated from partial national data.

Even though the development of a calibrated equilibrium forecast model for transport in Europe is beyond the scope of this project, a metamodel based on knowledge produce by existing models (model KTEN developed on the 4th and 5th EC Framework Programme) may be good enough for the strategic spatial approach needed.

Preparatory work includes review of existing traffics on roads and other modes, integration of traffics forecast in relevant European studies and the analysis of studies on transport bottlenecks.

The following intermediate results are calculated:

- Traffics on roads
- Traffics on railways
- Traffics on air routes
- Traffics on sea routes

The preliminary final indicators will include:

- Traffic crossing a region
- Congestion levels across regions by modes

Results will be presented in numerical form and in maps showing link loads and in maps showing the regional traffic load and regional congestion levels.

4.2.8 Transport externalities

At the same time transport is facilitating social and economic relations and is also generating environmental externalities that reduce and constrain the capability of a given region to attract new activities, as well as to some extend the productivity of the already existing. Accidents, land occupation, and air pollution are the most important strategic impacts of transport in this respect. Others are energy consumption, noise, car disposal, etc.

There are a number of estimates of these impacts and their economic cost in terms of per cent of GDP, for the whole Europe and most countries. The calculation of such impacts at aggregate level based on estimates and ratios from existing studies will complement the previously mentioned approaches to accessibility.

The provisional list of indicators includes:

- Accidents
- Energy consumption of transport
- Emission of green house gases
- Emission by pollutant
- Natural value of land-taken by infrastructure

Indicators will be presented in numerical form and in maps for regions and, depending on data availability also for links.

4.2.9 Network Vulnerability

Transport infrastructure networks and services are subject to a range of risks with respect to geographic situation, climatic conditions or human actions which may seriously affect their functioning. ESPON 1.2.1 will try to address the relatively new field of network vulnerability with a number of indicators describing the exposure of transport infrastructure to potential damage.

A current preliminary indicator list includes

- Geographic structural vulnerability of corridors
- Climatic vulnerability of corridors
- Anthropic vulnerability

4.2.10 Advanced Visualisation

The final category is different from the previous ones, because the focus is on advanced visualisation techniques. Based on previous developments of project partners a range of innovative mapping methodologies will be further developed in order to gain new insight in territorial aspects of transport infrastructure and services.

The current plan for advanced visualisation techniques include:

- *Three-dimensional accessibility surfaces* will visualise quasi-continuous spatial variation of indicators based on small raster cells.
- *Time-space maps* will demonstrate the 'space eating' effect of new transport infrastructure and services.
- *Chronocarts* will display different qualities of different transport modes in three-dimensional representations.
- *Animated map*s will show developments of indicators over time.
- *Hypermaps* will enable the exploring of the map databases to be generated in analogy to the concept of hypertext.

4.3 Indicator Integration and Development of Typologies

As far as the specific type of indicators allows, the indicators will be stored in a database for NUTS 2 and NUTS 3 regions or in databases for nodes and links for the territory of the European Union and for equivalent regions of the candidate countries. The database will contain the existing indicators generated in Work Package 3 and the new advanced indicators generated in Work Package 5.

In addition, analysis and mapping tools will be developed that allow the comparative processing of the indicators developed and implemented. These tools will allow the comparison of different indicators in numerical or cartographic form (e.g. daily accessibility v. potential accessibility), the combination of indicators to new indicators (e.g. passenger and freight indicators), advanced spatial analysis (e.g. cluster analysis) or the spatial aggregation of indicators to the level of NUTS 2, 1 or 0.

The system will necessarily use advanced software tools since the calculation of transport network indicators requires sophisticated algorithms and involve the management of large databases. State of the art tools, as standard as possible, will be used and compatibility agreements for metadata documentation and data transfer established among all participants in the project, and having in mind the dissemination process of results, to be made both in alphanumeric and cartographic formats. Hypermap techniques which use the same principle as hyptertext will be further developed in order to provide an easy access to the map database.

In this way, the different types of methodologies and transport and accessibility indicators developed in the project will provide an enormously rich database for the development of territorial typologies. On the one hand, it is possible to generate spatial typologies for single indicators, i.e. for specific purposes. Examples could be regions benefiting in terms of accessibility from investment in high-speed rail infrastructure and regions not connected or regions benefiting from international and intercontinental air connectivity. Some indicators can be expressed in maps only, here, innovative cartography will lead to an immediate recognition of spatial typologies. On the other hand, the tools for combining, aggregating and analysing the single indicators aim directly at the generation of sophisticated spatial typologies based on a variety of different transport related indicators.

The expected results of the final integration and typology step of ESPON 1.2.1 will be:

- A database for NUTS 3 and NUTS 2 regions, and also per transport terminals, with main indicators will be produced.
- Maps representing intermediate and final results will be produced.
- An integrated database with all data sources, reference material and studies will be developed and finally delivered as website, on a CD-ROM and as a paper report.
- A typology of the European territory with respect to transport infrastructure and services will be developed.
- Conclusions in terms of policy-suggestions will be drafted.

Chapter V Data requirement and co-operation with other ESPON projects

This chapter deals with data exchanges, that is why the requests and the cooperation were gathered. Indeed, the cooperation with the other TPG mainly shows itself by information exchanges in the form of raw data or partially or totally processed. Notably for example 3.1 Integrated tools for the spatial development, the exchanges are in both sense : data request and supply of results.

In the first time, we are going to set out our data requests, which were already presented to the ESPON Project 3.1. In a second time, we are going to widen the matter to all the themes directly linked and specified in the addendum of the subsidy contract that is to say projects 1.1.1 , 1.2.2 , 2.1.1 and naturally the 3.1.

5.1. Data requirement

Data needed by the group are two types :

- classic data for the study of transport networks corresponding to the first phase of our works : description of networks given what we know at the moment, on the whole observed territory EU27 and determining the various indicators and more particularly in the first phase of the existing indicators described in the chapter III.

- The less classic data allowing to finalize and to determine the values of the new indicators that we propose, as for example among many others, the climatic vulnerability of the networks which requires DTM's use (Digital Terrain Model) to determine the heights of roads in order to anticipate the floods effects …

5.1.1 The classic data necessary for the study of transport networks.

First of all, one precises that all of these data are not surfaciques but nodals and necessarily georeferenced, that is to say exactly localized.

One will naturally use at least NUTS 3 but this definition is not directly usable for the analysis of networks. These are defined in one GIS (Geographic Information System) as a polyline naturally with spatial reference with specific attributes.

It concerns all the features allowing the precise description of the punctual and linear infrastructures that form the various equipment networks.

These networks are either linear or punctual :

- The road network of free access in all countries, characterized by intersection, which are crossroads, cities following the considered scale and bows which connect them and are delimited by straight sections or curves representing the real roads.

- The toll/or not motorway network according to zones, characterized by a few interconnections, interchanges between it and the road network
- The rail network used by a specific rolling equipment
- The ship canals network and navigable rivers
- The maritime network which is essentially characterized by its harbour interconnections although there exists maritime lanes
- The air network characterized by its airports although there exists restricted air lanes

The most classic characteristics are the Euclidian distances between intersections, the network distances, the capacities in number of rows for roads and highways, in number and in type of plane for airports according to the weather conditions, in number of boats, draught and length for ports by taking into account the problems linked to possible tides.

From georeferenced intersections, the Euclidian distances are easily calculated. Knowing the network distances, the possible speeds, one calculates the matrix of distance of all point to all other point as well as the times of distance covered. If one knows the flows, one can deduct speeds from it (the opposite being uncertain because of the existence of two possible solutions).

The capacities indicate the maximum theoretical flows, real flows being inferior according to the outputq, one can deduct from it the power linear consumption, the emissions of gaseous pollutants and particles with greenhouse effect and harmful to health.

It is also about statutory type characteristics as the possible limitations of weight speed, congestion, (on road, on rail road size, on canal, on airport …), rates, bans of travels certain days or for certain types of vehicles, rates of tolls, the rules of work duration applying to the truck drivers.

At last, the frequencies and the schedules for the public transports are necessary in a certain number of applications which take into account the public transports (trains), or for the multimodal travels, like door to door or shelves ot shelves.

A certain number of these data is available in Eurostat for example but it is necessary to come down to a much finer spatial level. Any chain and particularly the one of transport has only the solidity of its weakest link.

The partners of the TPG 121 have access or possess data bases on networks, but they have to check, update and validate them.

For that, they ask for the free access to data bases GISCO, SAB, CORINE LAND COVER, which had been promised.

The TPG 2.1.1 develops a request of data for networks to which we join.

5.1.2 A finer request of data for new indicators

The third dimension is necessary for the problems of natural risks (floods, blocking by the snow etc.) of calculation of the pollutants emission by road traffic (private cars, heavy goods vehicles) to define heights and profiles of lanes. In fact we would need a precise MNT in the third dimension.

MNT's request has two main objects which do not require the same precision :

- The first one is the calculation of the emissions of pollutants by the road mode and mainly the heavy goods vehicles. Christophe Decoupigny, one of the PdD students of the CESA developed a software whose first results were used in the SPESP and which allows to calculate the emissions according to road profiles. Spikermann and Wegener has a tool of the same type.

These emissions can be deduced from a MNT of classic precision: that one of the IGN cards. It's the same for the risks of road closing as a result of snow coverage...

- The second one is linked to the vulnerability of networks and more particularly to the determination of the usable networks in case of flood. In that case the necessary precision is of the decimetrical order, therefore clearly bigger than the contour lines of a 1/25 000 map which are of the metric order. (A surverse can be caused by a level difference of the order of 30 to 50 centimeters for the Loire. We have the software (realized for the GIP hydrosystem) allowing to make it but not the data. I know that these ones exist and that the military MNT has a precision of this order but....

To illustrate the difficult problem of the data precision and the possibilities of transfer from a system to another one by crossing IGN and BRGM data, we notably found an error of the order of 750m in the localization of a bridge !

The difficulty of this kind of approach is in the big number of data to be processed on computers. One of the considered solutions to exclude this drawback is the use of fractals to generate a profile of the same features from a DTM for example.

Considering the climatic events of this summer, this aspect of networks vulnerability is very important and absolutely necessary to tackle. A second set is made up by schedules

A third set is made up by the necessary data to a multi-scale which will allow a network approach of the polycentrism problem.

The necessary data are the same than previously but in a much bigger scale, therefore at a much finer detail level.

In conclusion the necessary data for the 121 theme exist and are possible to get in order to complete, update data bases already at the disposal of the group. The difficulty will probably be for a DTM of a sufficient altimetric precision.

These data will allow us exchanges with the other groups and particularly the supply of a matrix of the distances and the times of travels that the TPG 121 could supply to all the other TPG that could need them.

5.2 Cooperation with other projects

Our group have or obtained necessary elements to be able to cooperate with the other groups

- His members are present in four groups at the moment - 1.1.1 , 2. I.I, 2. I.2 and 3.1 functionning on the seven others
- The French NFP is part of our project and has the responsibility to take charge of the cooperation with the other projects
- Lastly the group obtained a network-working software whose key access could be given in order to follow our works in real time.

5.2.1 Inter group Exchanges

The group 121 is represented in the other projects, and the cooperation has entered in one active phase, particularly with the 3.1. Even if in this phase of starting up, the various projects are concentrating on their internal cooperation quite at the expense of exchanges with the other groups.

Let us note however three particular cooperations in the ESPON.

Co-operation with ESPON project 1.1.1 "The Role, Specific Situation and Potentials of Urban Areas as Nodes in a Polycentric Development"

There is a clear relationship between ESPON projects 1.1.1 and 1.2.1. Both projects are dealing from very different viewpoints and to a different degree with the concept of polycentrism. ESPON project 1.1.1 has the task to come up with an operational definition of the concept of polycentrism in which territorial indicators on transport infrastructure and services such as accessibility play a role. On the other hand, ESPON project 1.2.1 has to take account of the concept of polycentrism when developing territorial indicators for describing transport infrastructure and services.

A close co-operation between the two projects is guaranteed, because S&W is a main partner in ESPON 1.2.1 and responsible for transport issues and accessibility in ESPON 1.1.1. An exchange of ideas, concepts and methodologies between the project partners of both projects will take place at the 1st ESPON Seminar on 21-22 November 2002 in Luxembourg.

Co-operation with ESPON project 2.1.1 "Territorial Impact of EU Transport and TEN Policies"

There is a strong linkage between ESPON projects 1.2.1 and 2.1.1. Both are dealing with transport aspects of territorial development in Europe. Whereas ESPON project 1.2.1 belongs to the thematic projects of the programme, ESPON project 2.1.1 belongs to the group of projects dealing with policy impacts on territorial development. Consequently, ESPON project 1.2.1 focuses on analytical approaches in the field of transport infrastructure and services and ESPON project 2.1.1 is concerned with forecasting methodologies dealing with spatial impacts of TEN-T developments. In both projects, transport infrastructure endowment indicators and the concept of accessibility play key roles and thus constitute common features.

A close co-operation between the two projects is guaranteed, because S&W is a main partner in both actions. An exchange of ideas, concepts and methodologies between the project partners of both projects will take place at the 1st ESPON Seminar on 21-22 November 2002 in Luxembourg.

With the 3.1 and at the beginning through our NFP Claude Grasland our NFP, a contact was formed at the level of lead partners, contact that should be developped quickly.

5.2.2 The importance of the NFP and the UMS RIATE

Although the means are setting up with slowness, the influence of our NFP is strong : he relieves the requests in both ways with the 3.1 in which he is part of it and he seems very anxious to get information, data, results of works of the other groups, then totally assuming his role.

Dr Peter Schön was authorized and then received keywords to have access to our networks-working groupware.

5.2.3 The use of a network-working groupware

On Alain L' Hostis's initiative, which settled on the INRETS Lille server a working groupware in the network, all the members of the group can consult the state of advancement of the works, almost in real time and put their own data. This software is much more transparent than exchanges of mails and it allows a much easier work in common.

However, it has another important usefulness (and this was only really understood with a first experience of internal work) : the contact with the other groups and the possibility for them to be very easily informed about the state of advancement of our works and questionning.

In fact one can authorizes anybody wished by giving to him the access keys. Naturally there are protections and levels of authorization. For example to intervene to amend a text is only possible for the members of the group. On the other hand an authorized person can import files.

After this trial period the authorization to consult are going to be generalized for everybody who will ask for it.

We think that this type of tool should be generalized in all the groups because it is a very good means of opening and of potential spreading.

5.2.4 Provisionnal conclusion on co-operation

The conclusion is full of hopes but qualified.

The group 1.2.1 effectively gave itself the means of diffusion and the cooperation through men, institutions and the networks and it shows its will to continue in this direction.

But the nuance is that the means are not enough if this will is not taken into account, not relieved from outside or more simply elements to be exchanged were not gathered yet because we are only in the initial phase of the project with two months of real functioning. Time is necessary so that the process starts and forms itself. One could bet that after the meeting in Luxemburg the exchanges will be much more intense.

Chapter VI Expected results

The expected results and the date of which they are expected can not be divided because the constraint of time determines the choice of the priorities in results.

In view of the chosen dates for the delivery of the intermediate reports and furthermore it was orally confirmed to us during the preliminary meeting in Brussels at the signature of the subsidy constract, now it is clear that this timetable was imposed by external constraints to the program itself. The revision of Structural Funds and the necessity of having results for the summer period 2003.

This revision offers the possibility of introducing Spatial and Planning Policies, which were not legally justified previously but possible since its integration in the Amsterdam Treaty of the " territorial cohesion".

The TPG 121 perfectly integrated this constraint as we will see it below, and the presence of an planner as a leader can only facilitate its understanding: it is fundamental that the territoriality and the space can be integrated into the Community Policies.

The time is then here the main constraint and it largely determines choices on the nature of the scientific production, the principle being clear, it is necessary to be aimed at the efficiency, to produce at once reliable results with already tested indicators, use and reserve for a second time the more unpredictable finalization allowing results for which we hope to be more precise and adequate though.

We will then see in a first section the temporal constraints and in a second one the foreseen results by period.

6.1 Temporal constraints of the ESPON programme

These constraints are clearly identified in Addundum Annex 1 of the Subsidy Contract :

Updated minimum requirements on results and timetable (ad Term of Reference point (v) on expected results and time table) (non paginé)

- October 2002 (first interim report)
- March 2003 (second interim report)
- August 2003 (third interim report)
- August 2004 (final report)

It is clear that the disparity of periods between the various reports is significant, independently of orally supplied explanations as additionnal information.

Three reports per year, and, one year later the final one, obviously show a practically short-term concern which corresponds to studies and a medium-term ambition at the level of a research.

The TPG 121 got organized according to this analysis and schedules its works as a consequence:

We will develop all indicators at NUT3 for all regions and transfer them to 3.1 so they can disseminate to the other groups. Advanced indicators will come in 2003. But **we recommend not waiting until the end of the project to get final analysis but producing indicators and preliminary analysis as soon as possible.** So we will send our analysis to 3.1, but we will also develop bilateral contacts with each interested group.

The program is then defined: we begin at once to produce classic indicators and a first analysis (temporary) that we will spread as soon as it is achieved through Glaude Grasland, through the 3.1 and through our software on the network that will be available for consultation by everybody who is interested (it will be naturally automatic for ESPON's authority of Luxemburg) without waiting for a possible supply of a common data base through the group 3.1 and through ESPON.

This point is developed in the second part of the chapter.

The concerned indicators are those described in chapter III Existing indicators: they will essentially concern the current state of networks, and the projects which will be achieved for 2010.

The forecast for 2020 will be made at the same time as the research on the advanced indicators

As soon as we get the results, we will begin the finalization and the determination of the advanced indicators, as early as possible in 2003 in order to be able to state new results for August, 2003.

6.2 Expected Results

6.2.1 Existing indicators

In terms of principle, we need the analysis from other groups as they need ours. But from the point of view of the group on transport services and networks, we need analysis from all groups.

As we have already mentioned in the preceding chapter, the members of the TPG 1.2.1 already have their own database. It is a question of checking and of completing them, and for that we need databases requested through the ESPON 3.1 group.

We provide lists of transport nodes (ports, airports, railway stations) and data attached to 3.1 for any group interested. Those data are available for the TPG members from the tool managed by INRETS.

Mcrit propose to consolidate among the TPG a single database for transport nodes improving Mcrit database and making it the common database in the TPG for transport nodes.

Then the data can be transferred to 3.1 in order to let them integrate with GISCO databases.

Once these bases checked, we will estimate all the indicators mentioned in chapter 3. From this work analysis will be in possession of a classic, strong analysis of transport systems in Europe, analysis that we could improve afterwards according to new data and indicators.

This first part of work will naturally allows us to get series of matrix origin/destination in Euclidian distance, in network distance, in time and costs, with associated maps notably the more elaborated maps as Chronocartes from Alain L' Hostis, cost cards (costmap).

Matrixes integrating the social rules concerning the driving periods of drivers and the circulation interdiction constraints for lorries will complete these traditional matrixes. These new elements will bring the models much closer to real conditions. These conditions illustrates one of the reasons explaining the high level of fraud, as well as the interest to engage foreign drivers to avoid the constraints of the rules leading to distortions in the market.

These matrixes will be applied on road and motorway networks, producing maps, classical or more complex cartographic outputs.

These matrices will be at the disposal of the community, directly or through the group 31.

As soon as they are available and checked, they will be available for consultation by the TPG members on the ESPON 121 website.

This first analysis will allow us to identify temporary conclusions on networks, flows, gridlock, capacities, infrastructure requests and the use of infrastructures.

One of the most promising results of this analysis with existing indicators is the fractal dimension of networks. This constitutes one of the only topological indicators that be synthetic and usable. Introduced by Pierre Frankhauser and developed by Cyrille Genre-Grandpierre, the fractal dimension allows to characterise the shape of the network. It has been applied on cities and we wish to apply it on regional networks, in order to bring a new light territorial cohesion, based on the topology of transport networks.

6.2.1.1 The results in terms of goods transport

The consideration of candidate countries will allow on the short- average term, year 2010, to study the effects of it on central countries, inevitable geographically, and which have a "crossroad" role.

The international is certainly clearly lower than the interregional but an analysis in marginal term can point out, from the only fact of the international traffic increase, of the local saturations in the most vulnerable zones, i.e the most saturated ones.

These various elements will allow to develop a first approach, still rather rough –due to the probable difficulty to obtained a detailed DTM– of energy consummations and pollutants emissions along the international corridors. These results will also be exposed under cartographic representation.

A first approach of intermodal transfer will be developed.

At this level, we will be able to evaluate the decided and the proposed infrastructure improvements.

It will also be possible to evaluate the possible changes in the rules: size, weight and speed of vehicles, driving periods, interdictions of circulation, effects on the modal and spatial repartition of flows, projects of road pricing based on GPS, etc.

6.2.1.2 The results in terms of transport of persons

In the domain of the transport of persons, the matrixes of network distances, of costs, of travel times, modal and multimodal flows will be computed and available on the ESPON 121 web tool for the TPG members.

The flows will be spatially affected, including the railways.

A part of the analysis described before will be conducted for both types of use, goods and passengers.

Concerning the networks in polycentric spaces, the nodal zoom developed by Laurent Chapelon will be very useful. The expected result concerns the possibility to change from one level of analysis to another, and to focus on “intra-polycentrism”, on the movements of persons in these polycentric areas, possibly through flows modelling.

The group can give to the other projects a new type of 3D-cartogram based on principles close to those of the chronocartes. The advantage of this system is never to provoke topological breaks even when it is used on very big scales of variations as the one of NUTS5.

6.2.2 Advanced indicators

The purpose of the advanced indicators proposed and developed in chapter 4 is to precise the classical analysis, to widen their field of application, to tackle new phenomena still not enough explored and measured, to focus on the issues of vulnerability, to appreciate the quality and the level of service, to assess alternative solutions, in order to propose a better decision help for policy choices.

Nevertheless, because of the lack of demonstration or the hypothetical character of some of these indicators, it is still difficult in this first interim report to precise completely the expected results, especially before testing. At his moment, whether they have been exploited at local scales and they have to be extended before validating the range of application, whether they are existing indicators not tested by lack of data, or simply by their hypothetical character.

Consequently, the efficiency of these indicators can only be presumed. The validation will be conducted in the second and third interim reports.

Because of this difficulty to predict the efficiency of some of these new advanced indicators, the group has decided to start working very soon, without to wait for the availability of the common ESPON database.

Nevertheless, if this database is provided to us in soon enough, the group will use it for all the indicators developed, in order to favour the scientific character of the approach based on verification and possible reproduction.

One of the expected results in this phase will be to attain the most complete objectivisation possible, based on the transparency of the computing methods and the precise description of the data used.

VII Conclusion: work plan and key points

7.1 The work plan

The subsidy contract and the addendum imposes three major constraints for the theme 121 of the ESPON "Transport services and networks: territorial trends and basic supply of infrastructure for territorial cohesion"

- The geographic area to consider : the countries of the European Union, the candidate countries, the neighbourhood countries Norway, Switzerland and Iceland. It must be noted that the notion of territorial cohesion defined in the Amsterdam treaty allows the introduction of a spatial policy and gives a justification to the spatial planning decisions that had, before that, no juridical basis. Concerning the transport issues, the territorial cohesion supposes the creation of new relations between networks and between territories, and beyond the administrative boundaries constraints, (NUTS 2, NUTS 3, etc) the creation of relations between spaces. From this statement, one can appreciate the importance of spatial planning strategy, which has implications at the continental scale, and at the national and infra-national scales. The European spatial planning implies the coordination of the national transport policies in order to facilitate the movements of men and of goods. Each partner must then be responsible for a geographic zone including several countries, which is also necessary if we compare the number of partners to the higher number of countries to consider.

- The various networks and transport modes, terrestrial road and motorways, rail, inland and sea waterways, and also air, for both passenger and goods must be considered. This constraint is strongly reinforced by a major objective: the complementarity of modes and the modal shift that constitutes in the same time an ambition and a necessity for many reasons. The taking into account of the various networks is done at the continental scale (EU 27 plus neighbours) but also consider the regional level since the territorial cohesion is wished, and also the local levels to address the polycentrism question. This work has to be done in close cooperation with the themes 111 Polycentric Development, 122 Communication, Energy, 211 Infrastructure Policy, and finally 31 Integrated Tools for the Spatial Development. According to the indications given at the Bruxelles meeting, and as stated in the chapter VI Expected Results, the results of our work will constitute inputs to the discussion on the redefinition of the structural funds. It is then necessary that the core group of partners, who contribute the most to the research –data collecting, treatments, producing indicators, presentation of results submitted to evaluation to all project partners– have a multimodal approach. Consequently no modal specialisation has been introduced in the TPG.

- Finally, the subsidy contract and the addendum fixes the dates and indicates the global themes of the reports. Nevertheless, each of the partners participates in the producing of each report, according to the constraints mentioned precedently. In order to allow simultaneously the expression of the diverse opinions in the group, the opportunity for each one to learn or improve its capacity to co-operate, and the emerging of a final converging position on the issues studied, it has been decided to distribute the responsibility of the intermediate reports. In this way, each main partner has the opportunity to deepen its own specific approach, to be in charge of the organisation of the debate during a certain period, and of the provisional synthesis of the report.

These three sets of constraints, expressing the views of Bruxelle's authority through the ESPON process, have lead us to a superposition of three organisational structures: a thematic distribution, a geographic coverage, and finally a distributed responsibility concerning the deliverables, under the global responsibility of the lead partner.

7.1.1 A geographic distribution of the work

Each partner in the Transnational Project Group is attached to a geographic area including a group. The European Union and the candidate countries are covered.

- Christian Reynaud (NESTEAR): France
- Andreu Ulied (MCRIT): Spain and Portugal
- Alain L'Hostis (INRETS) : Great-Britain, Ireland
- Dimitrios Tsamboulas (SYSTEMA): Greece, Macedonia, Bulgaria, Rumania and the oriental Mediterranean (Aegean Sea) as well as the West of Black Sea.
- Paola Pucci (Politecnico di Milano): Switzerland, Austria, Hungary, Slovakia and Northern Italia
- Peter Cardebring (TFK Transportforschung GmbH): Baltic Sea, countries of the North of Europe, Finland, Sweden, Norway, Iceland, Denmark, the Baltic states and Poland.
- Umberto Petruccelli (DAPIT): South Italy, Sardinia, Sicily and countries of ex-Yugoslavia : Slovakia, Croatia, Bosnia Herzegovine, Serbia and Albania

Each expert has in charge the validation of data, on its defined geographic zone, concerning road, rail, air and waterways. When necessary he gives help in the access to data in identifying the sources and the content, completing the knowledge provided by the Data Navigator.
At the final stage, the partner validates the results obtained and the policy indications concerning the specific area.

See the map in annexes below.

7.1.2 A thematic repartition of the work

In the Transnational Project Group, the partners have thematic responsibilities.

- Passenger transport is coordinated by Klaus Spiekermann,
- Goods transport is coordinated by Christian Reynaud.
- The global system integration is assumed by Andreu Ulied.
- Cartographic developments are coordinated by Philippe Mathis and Alain L'Hostis.
- Quality, effect of rules, multiscale multilevel representations Philippe Mathis and Alain L'Hostis

7.1.3 A temporal distribution of the synthesis work

Accordingly to the eight work packages developed below, the temporal distribution of the responsibilities of contribution and synthesis reflect the principles exposed before. The distribution of the work packages reflects the share of the roles in the Transnational Project Group:

N°	WORK-PACKAGES	CONTRACTORS
WP1	***Project Management***	**CESA-INRETS**
WP2	***State of the Art***	**CESA**
WP3	***Preliminary results with existing indicators***	**CESA**
WP4	***Definition of new concepts, methods and advanced indicators***	**NESTEAR**
WP5	***Implementation of advanced indicators***	**S&W +(** Mcrit)
WP6	***System integration***	**Mcrit +(**S&W)
WP7	***Mapping, presentation and dissemination of results***	**CESA-INRETS + UMS RIATE**
WP8	***Policy recommendations and conclusions***	**CESA-INRETS**

Note that the responsibilities for the WP 5 and 6 was fixed during the kick-off meetin in Tours.

The WP will produce inputs for the four reports that has to be deliverd during the two year of the research.

So, the planned calendar of the tasks is the following:

D1	***First interim report: State of the Art***	**WP2**	***CESA INRETS***
D2	***Second interim report: Preliminary results and concepts***	**WP3** **WP4**	***CESA-INRETS*** ***NESTEAR***
D3	***Third interim report: Main results***	**WP5**	***S&W***
D4	***Final report: Policy conclusions and integrated system for monitoring***	**WP6** **WP7** **WP8**	MCRIT ***CESA-INRETS+UMS RIATE*** ***CESA and all partners***

If one or several partners are responsible for a work package, each partner participates in all the work package.

In addition to this global framework, some partners will carry a more specific contribution. Umberto Petruccelli will work on the base accessibility indicators and their employment in aggregate indicators.

Paola Pucci, in association with Alain L'Hostis, will work on how road, rail and air passenger transport networks can be mobilised to support the polycentric development option, and especially the "cities networks" pattern.

The temporal organisation of each theme is constrained by the schedule of the deliverables, and reflects the temporal phasing exposed in the chapter VI Expected Results.

The concentration of the three reports on four during the first year of the research demonstrates the major importance given to the results to be produced in August 2003, date closely linked to the discussion on structural funds.

REPORTS	MEETINGS
First interim report : October 2002	*-Partners : July 2002*
Second interim report : March 2003	*-Partners and subcontractors : November 2002* *- Partners : January 2003*
Third interim report : August 2003	*-Partners and subcontractors : May 2003* *-Partners : July 2003*
Final report : August 2004	*-Partners and subcontractors : February 2004* *-Partners :June 2004*

The responsibility on the synthesis by the main partners reflects the timetable decided by the commission.

Nevertheless, this responsibility is not only theoretical: the fact that the synthesis effort is made by each partner after a phase of research in its own thematic implies a real surpassing.

7.2 Key Points

This first interim report aims at to representing the various dimensions of the approach developed in the Transnational Project Group ESPON 1.2.1.

“Transport services and networks : territorial trends and Basic Supply of Infrastructure for Territorial cohésion »

As an introduction, we have first presented the fundamental objectives of the ESPON and of the theme. Then the team constituting the TPG has been presented.

In a second chapter, the policy orientations in the fields of transport and planning have been detailed.

Existing indicators have been reviewed, and the concepts and methods related to the advanced indicators that we plan to develop in order to address the relevant issues have been presented.

Then we have discussed the necessity to get the relevant data from the ESPON and to support a close co-operation with the other projects, that are simultaneously providers of data that we need and users of our results.

Finally we have tried to present the expected results at this stage of the research.

As a first point of the conclusion, we have detailed the organisation and the work plan as guided by our aims and by the specificity of the approach chosen. At the end of this first interim report, what are the key points that are important enough to be underlined?

What is the specificity of the Transnational Project Group approach?

Maybe firstly, the fact that the TPG is constituted of a core of researchers, of experts who know each other and that have learned to work together in other projects.

The second characteristic, more specific, is the type of organisation chosen in the TPG that is based on a thematic criterion, on a geographic coverage principle and a temporal distribution of the tasks to accomplish and of responsibilities to assume, each one having its own competency as a specialist, and having in charge a work of synthesis.

The third characteristic is a deep understanding of the constraints and the objectives of the ESPON as a project, and the will to assume them.

The immediate consequence of this points is our will to engage the work with our own data, without to wait for those that the ESPON will be able to provide.

If the ESPON data are made available to us, and we wish this for the reasons exposed above, we will use them to complete our mission, in the most objectivised and scientific way.

The aim of our will to start now the assessment of the networks and services in relation to the objectives of the spatial planning policy is to provide the help necessary for decisions that will be taken *before* the end of our present research work.

Amongst the issues that we want and have to address in terms of "transport services and networks" one must mention:

- The concentration of traffic in the central countries, with unavoidable transit functions, and its consequences.
- The modification of the spatial equilibrium with the enlargement and the modifications to the polycentric structure.
- The issues of peripheries which risk to deepen their gap with the core areas, as well as the gaps between them, with for instance the Atlantic Arc versus the Baltic arc.
-

It is unusual to have to provide almost definitive results halfway through the period of the research. There is here a risk that we will do our best to avoid. The period between August 2003 and August 2004 will be necessary to systematically and theoretically validate the indicators developed and presented collectively in this first interim report.

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