TEN-T POLICY REVIEW

EXPERT GROUP 1 ''METHODOLOGY FOR TEN-T PLANNING''

Proposal on TEN-T Network Planning

Final Document

1. Introduction

The TEN-T network is called on to contribute to achieving a wide range of goals. These include the sustainable mobility of persons and goods and the enhancement of both the internal market and the global competitiveness of the Community, while at the same time ensuring territorial, economic and social cohesion, social welfare, safety and security for European citizens and innovation, as well as taking into account environmental aspects such as climate change, pollution and protected areas.

In its Green Paper "TEN-T policy review – Towards a better integrated trans-European transport network at the service of the common transport policy"[1], the Commission had proposed three planning options and stressed the need to enhance the relevant financial and non-financial instruments to ensure effective and timely implementation of the TEN-T. The public consultation and the positions of the EU institutions and consultative bodies showed very strong support for the third option, based on two layers: a Comprehensive Network and a Core Network.

While the fairly dense "Comprehensive Network" of rail, road, inland waterways, ports and airports, made up of significant parts of corresponding national networks, would be maintained as the basic layer of the TEN-T, the "Core Network", as a subset of the Comprehensive Network would overlay it and give expression to a genuine European planning perspective.

Starting from a very first proposal prepared for the first meeting of this expert group on 27 October 2009, this methodology has been developed step by step, taking advantage of the suggestions and comments of the members of this expert group.

This paper reflects the final status of development of this methodological approach, following the fourth and last meeting of the group, which took place on 9 March 2010.

[1] COM(2009) 44 final, 4.2.2009

2. The Comprehensive Network

As in the past, the future Comprehensive Network should ensure accessibility of and access to the core network, and contribute to the internal cohesion of the Union and the effective implementation of the internal market. It should address the following needs: a reference for land use planning; a geographic reference for other policies; a target for technical and legal requirements on interoperability and safety; the accommodation of technical standards to enable effective modal integration with the aim of door to door co-modality.

The Comprehensive Network should link all EU regions in an adequate way, be multimodal and provide the infrastructural basis for co-modal services for passengers and freight. Since the Comprehensive Network will be the basic TEN-T layer, it must cover all elements of the future core network. When planning the future comprehensive network, the following criteria should be applied, starting from the current comprehensive network:

- Update the current network to reflect the progress in its implementation and adjust it where necessary to changes in national planning;

- Add selected and well-defined missing links which are necessary to ensure homogeneous network planning and the interconnection of national networks, and to contribute significantly to the TEN-T objectives;

- Eliminate dead ends and isolated links;

- Ensure that elements of the TEN-T or transport policy "acquis", which are not consistent with the new core network planning methodology (see below), are covered under the comprehensive network[2].

A requirement for any element of the Comprehensive Network is compliance with the relevant Community legislation in the transport and other sectors, including technical specifications on rail interoperability, tunnel safety, etc.

On the basis of the above criteria and conditions, proposals for planning Comprehensive Network elements may be made by Member States concerning their respective territory. All proposals will be discussed bi- and/or multi-laterally.

[2] This might, for example, concern a limited number of individual sections of priority projects, ERTMS or rail freight corridors.

3. The Core Network

The Core Network represents a long-term target, affordable over time that can give a stable orientation to its step-by-step implementation. It shall be multimodal at the level of both nodes and corridors, facilitating intermodal transhipment and efficient and sustainable co-modal mobility and logistic chains. It should comprise those parts of the Comprehensive Network which are of high strategic importance for the Union.

It will consist of two pillars, each at the same strategic level. Alongside the Geographical Network Pillar, it will include a Conceptual Pillar, to provide the infrastructure basis necessary for the achievement of various policy objectives in the transport and related sectors. The Core Network is intended to allow the identification of clear strategic priorities for its development in support of the Union's objectives, as defined in the Treaty.

The overall objective of the Core Network is to enhance the "European added value" of the TEN-T. This is defined as a benefit that goes beyond those achieved at national level and includes not only economic benefits, but also those derived in the cohesion, environmental and safety and security areas.

The Core Network should be conceived as a functional network, reflecting the long-term needs of the Community, and should therefore remain stable over a reasonably long period, to allow investment needs and projects to be derived from a Europe-wide perspective[3].

Accordingly, the Core Network shall be developed on the basis of a methodology which reflects, as far as possible, the state of the art in strategic infrastructure planning, taking into account the various objectives laid down in the Treaty on internal market and global competitiveness, territorial cohesion, sustainable transport and decarbonisation.

The elements of the Core Network would be eligible for funding, in line with a step-by-step implementation strategy, based on a proper calculation of priorities according to needs and available funding volumes. The Core Network is however primarily an instrument for development planning and not for funding alone.

In developing the strategic network planning methodology, both the basis and the spirit of the key criteria derived from the Treaty need therefore to be taken into account appropriately.

3.1. The Geographical Pillar

The geographical pillar of the Core Network shall:

- span the entire EU in a coherent way, with the individual elements linking up to form continuous axes, reflecting wherever possible relevant existing or potential long-distance and/or border-crossing traffic flows, without giving automatic preference to any particular spatial orientation,
- include the main gateway ports and airports,
- connect the important nodes within the EU, and
- be linked to the corresponding infrastructure in neighbouring countries and regions, in order to connect the Union with the markets beyond its borders.

[3] In this sense it is very different from the current approach based on 30 Priority Projects, derived in many cases from specific construction projects proposed on an individual basis.

It will therefore be made up of nodes and links of high European strategic importance in the geographical sense, taking into account the specific needs of different kinds of traffic such as passenger and freight, whether bulk or containerised, along major long-distance and international corridors, including traffic flows to points outside the EU.

Consequently, future revisions of TEN-T should be confined as far as possible to the step-by-step realisation of the Core Network, through updating priorities at the project level, in line with progress in implementation.

3.2. The Conceptual Pillar

The conceptual pillar, included in the Core Network alongside this geographical component, will comprise a methodological tool to allow, on a flexible basis, the inclusion into the network of non-geographical technical or infrastructural attributes to enhance its efficiency of operation, consistent with the objectives of EU transport or other relevant policies, such as de-carbonisation, interoperability, safety and security and sustainability. These could include the necessary infrastructure components for efficient capacity management, including innovative technologies and ITS applications. The topics of the Conceptual Pillar were identified and discussed in depth in expert groups 2 and 3.

4. The Core Network Planning Methodology

Within the TEN-T policy review, the establishment of a scientifically-based, transparent planning methodology constitutes a first key stage in identifying the elements of a sustainable, strategic, multimodal Core Network for the European Union and its neighbouring countries or regions. Such a methodology must be based on criteria that are consistent with the various relevant objectives laid down in the Treaty. Since there are conflicts between these objectives, for example between economic efficiency on the one hand and cohesion and climate protection on the other, a balanced approach is required in order to enhance overall sustainability. Accordingly, efficiency, in this wider, socio-economic sense, could be defined as maximising the achievement of a balance of the relevant objectives, for a given level of costs and effort.

The question arises as to whether to follow an approach that is more geographically- or more transport demand-oriented. However, this conflict may in fact be more artificial than real, since functional correlations may be assumed between spatial distribution of land use, population and economic activities and transport flows, leading to similar results from either approach. Including geographical elements into the methodological approach allows the pursuit of important strategic objectives at the European level, such as economic development and the reduction of disparities, in particular in peripheral, insular or landlocked regions, spatial balance of concentration and the creation of acceptable and sustainable environmental conditions. Furthermore, the chosen approach, based on the selection and connection of main nodes, avoids the need to determine thresholds.

4.1. Main Criteria

Transport policy, including relevant legislation and infrastructure pricing, has a significant impact on overall traffic demand and on modal choice. It is beyond the scope of the current TEN-T policy review to decide on the general legal and political framework. For this reason, it might make sense to distinguish between two basic scenarios: a "baseline" scenario assuming the continuation of transport policy as it is, except for modifications already decided, and a "sustainable Europe" scenario, comprising a series of political measures to enhance economic, social and environmental sustainability, including the effective internalisation of external costs of transport. These scenarios would be fully in line with those defined for the sustainable future of transport White Paper. Core Network planning would then be carried out for these two scenarios in parallel, showing the impact of different political frameworks on traffic demand and infrastructure needs.

To follow a sound methodological approach, a clear distinction will have to be made between, on the one hand, criteria relevant for selection of network elements to identify network configuration and, on the other, criteria for dimensioning and equipping those network elements, some of which would derive from the "conceptual pillar". Objectives and indicators must also be clearly distinguished, particularly when assessing the network with a view to optimizing its overall socio-economic efficiency.

General principles applying in network design at all strategic levels, including the Comprehensive Network, include:

- Multimodality, including intermodal links and facilities for co-modal and/or combined transport,
- Interconnectivity and network optimisation,
- Interoperability and improved efficiency of all modes of transport,

- Sustainability, including through CO_2 savings due to infrastructure measures,
- Attention to climate change-proofing of infrastructure,
- A focus on quality of service for users,
- Safety and security of transport infrastructure,
- Application of advanced technologies and ITS, and
- Minimisation of investment, maintenance and operational costs, while nevertheless meeting the criteria below in a balanced way.

Criteria for shaping network configuration:

- **Geographical or spatial aspects:**
  Spatial integration and accessibility, defined as ease of access to markets, are key elements for territorial, economic and social cohesion[4].

  Applying this criterion, it should not however be forgotten that accessibility is only one in a set of factors relevant for location quality. Improving the accessibility of a region is most effective if a region is also sufficiently endowed with other relevant factors of location quality, such as invested capital, fixed assets, sufficiently skilled human resources etc. Otherwise, increased accessibility may be ineffective or even counterproductive, possibly leading to erosion of economic and social benefits.

  Improving accessibility for peripheral regions does not necessarily mean the construction of transport infrastructure within those areas but rather towards them, thus not excluding measures in central regions of the Union.

- **External and global trade flows:**
  The large ports and airports and the major overland corridors to neighbouring regions are the main gateways of the Community and, as important links of global trade and travelling, will be natural elements of the future Core Network.

  Appropriate ground access for international airports is important for a competitive, sustainable and coherent European transport network.

  Improving infrastructure and services in Mediterranean ports, including their hinterland connections, could lead to a long term shift from the North Sea to the Mediterranean ports of a part of the freight flows from/to Asia, depending also on capacity constraints of hinterland infrastructure in North-Western Europe and likely increases in fuel prices. Shortening transport routes through a reorientation of global cargo flows may also be beneficial with respect to the de-carbonisation objective. Should melting of Arctic ice continue, the North-East Passage might in the future also be an alternative route. For more urgent cargoes, the routes through Russia or Central Asia are a further alternative for the future.

- **Passenger and freight traffic flows and customers' needs:**
  As TEN-T addresses itself to the internal market and international trade, it is evident that it is the long-distance and/or border-crossing traffic volumes which are relevant for the selection of the elements of the future Core Network.

  Apart from natural growth, due to economic development, potential growth could be affected by a number of different factors, including the impact on choice of route of the availability of new infrastructure, new traffic demand induced directly or indirectly by new or improved infrastructure, and the impact of transport policy

[4] Making accessibility patterns more homogenous throughout the Community, including by overcoming natural and administrative barriers, is assumed to contribute to reducing economic and social disparities, insofar as accessibility deficiencies are the reason for such disparities.

measures, such as internalisation of external costs, on overall and/or modal demand. Higher growth rates may occur in international air traffic.

Network shaping has to offer sufficient speed and capacity to permit a high level of service and to allow smooth operation, short travelling times for passengers and reliable logistics chains for freight.

- **Inter-connectivity and multimodality of the network:**
  The Core Network configuration should be coherent, allowing direct interaction between the individual links, not only along certain corridors, but also for traffic changing from one corridor to another. Seamless inter-connectivity between the available modes should also be foreseen at all major nodes of the Core Network, to enhance co-modal mobility and logistics chains.

- **Ecological issues:**
  Reducing greenhouse gas emissions or de-carbonisation is a major policy objective, which has relevance for all modes at all strategic planning levels. Accordingly, TEN-T Guidelines should support initiatives aimed at decreasing the transport system's carbon footprint. This includes traffic shift to modes with lesser specific emissions, measures to make traffic flows smoother and more efficient and, last but not least, the application of new or improved propulsion technologies (electricity, hydrogen) on all modes.

  As far as possible, infrastructure development has to avoid impairment of land, in particular of protected areas, and to contribute to minimizing the environmental impacts of traffic.

  While flanking measures are especially appropriate to mitigate local impacts such as pollution and noise, it is modal choice, apart from innovation in vehicle technologies, which is most decisive for climate change-relevant emissions. A strong impact on modal choice, in many cases exceeding that of infrastructure measures, may be expected from general transport policy changes such as infrastructure pricing regulations. However, the availability of new or upgraded infrastructure links can also have significant effects on routing and on modal choice.

  In order to achieve sustainable and efficient co-modal operation, it is indispensable to provide multi-modal terminals in adequate locations, generally within the important nodes of the network.

<u>Criteria for dimensioning and equipping network elements:</u>

- **Passenger and freight traffic demand, customers' needs:**
  Dimensioning of network elements must be based on reliable calculations using a suitable model for both analysis and forecasting, taking into consideration changes of traffic demand and modal choice or routing, due to improved or new infrastructure.

  However, the current economic downturn makes it difficult to predict future traffic development with any confidence. It is evident that as a minimum a certain delay in development has occurred, with corresponding influence on priorities for project implementation.

- **Removal of bottlenecks**:
  Bottlenecks are relevant if they affect long distance or international traffic flows, even if caused by regional or local traffic, in particular in nodal areas. Generally, they may be removed by increasing the capacity of the existing infrastructure, but there may be

an alternative in the construction of new links or bypasses. However, any possible demand push effect on traffic has to be taken into account.

- **Reduction of travelling times and improvement in punctuality and reliability:**
  Operational speed is mainly a function of alignment parameters (principally curve radii), while capacity depends on the cross section (e.g. number of lanes or tracks), and on local particularities such as road crossings and rail turnouts. However, there is a relationship between capacity and speed, as vehicles above a certain level of density can circulate only at reduced speed and capacity falls if vehicles circulate at different speeds.
  In a multimodal mobility or logistics chain, the interfaces are of key importance in terms of both infrastructure and services.

- **Ecological issues:**
  At the level of the individual network elements, the emphasis lies rather on minimizing impacts on sensitive or protected areas and flanking measures, to reduce or mitigate local noise and polluting emissions. Nevertheless, service quality should be sufficient to secure smooth traffic flows and keep greenhouse gas emissions to a minimum.

- **Traffic safety:**
  Safety aspects have to be considered already at the planning stage, by applying appropriate technical parameters for design and equipment of TEN-T roads and road tunnels. Furthermore, the necessary roadside equipment, such as kerbs, guardrails, fixed obstacles at the roadside, traffic-signs etc. should be designed and located to minimize danger to infrastructure users.

- **Traffic management, logistics, co-modal services:**
  For better use of existing infrastructure and for enhancing efficient and sustainable mobility and logistic chains, innovative cross-modal ITS equipment should be foreseen, according to the provisions established within the framework of the Conceptual Pillar.

4.2. Main Steps

The determination of the Core Network becomes a step-by-step procedure, identifying the relevant main nodes, which determine the Core Network basic configuration, as the first step. As a second step, the links connecting the main nodes have to be determined, following a string of intermediate nodes, so as to obtain an optimal network shape. As a third step, adequate levels of service and capacity needs for each individual network component, according to its function and traffic demand, have to be defined, taking into account the share of long-distance and/or international traffic in the total. Finally, to fulfil the requirements of operators and users, a certain level of service should be reached by equipping the Core Network and, where necessary, parts of the comprehensive network as well, with relevant complementary or auxiliary hard or soft infrastructure, as identified within the "Conceptual Pillar".

4.2.1. The Nodes of the Core Network

The Core Network shall be built up from main nodes which play or might potentially play some key role in European geography. These main nodes will span the Core Network polygon, determining the overall configuration.

Most of these main nodes will be represented by important cities - the capital cities of the member states, acceding countries and neighbouring countries - and other major cities in or around the Community, with high supra-regional importance in the administration, the economy, social and cultural life and transport[5].

Gateway ports or port clusters and airports as the Community's main entrance/exit points for freight and passengers shall be main nodes as well, if they are not parts of main node cities, anyway.

In European transport geography, there are also minor cities which, purely due to their location and connectivity within the existing network, have a particular function as "natural nodes", which should be taken into account when identifying the Core Network

In general however, minor cities, differing in location, in type and degree of industrialisation and productivity and in their functionality and importance in the transport sector, should be integrated into the network as intermediate nodes, by stringing them along the links in the most appropriate way, if of course they are located in a corridor between main nodes. Equally, the larger mining and industrial clusters, ports and airports of more regional importance or freight terminals should be treated as intermediate nodes as well, provided this is justified by their importance for passenger and/or freight transport or for cohesion. Basically, the same applies for railway stations; however are these in almost all cases embedded in city nodes, so it is rather a question of their local access. Where appropriate for network design, ports or airports may be considered as “clusters” rather than individual entities.

Urban nodes, apart from their other various economic and social functions and regardless of whether they are main nodes or other cities, have a complex set of functions in the transport system for passengers and freight, connecting:

- the links of the network, including those of the comprehensive network;
- the relevant modes of transport;
- long distance and/or international transport with regional and local transport.

For ease and speed of transit, transhipment and change of direction or mode, these intra- and intermodal linkages within the nodes need to be organized in the most direct and effective way. To allow co-modal freight logistics, smooth, fast and cost-effective transhipment from one to another mode should facilitate regional or local collection and distribution by road (the "last mile", including urban distribution) and long-distance transport on rail or inland waterway.

In public passenger transport, railway stations should have maximum accessibility within regional and local transport systems, to provide sustainable and attractive mobility chains, according to customers' needs and to reduce congestion and environmental impacts.

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5 e.g. European Spatial Planning Observatory Network (ESPON) – “Global Nodes”; "MEGA": Metropolitan European Growth Areas; "FUA": Functional Urban Areas. Cf. ESPON Atlas 2006

Traffic tends to reach its maximum density in urban agglomerations, causing congestion, noise and pollution. The integration of transport infrastructure into the local surroundings is therefore most challenging in such areas, if we are both to protect population from negative impacts and, at the same time, to provide the necessary easy access.

In passenger transport, airports, typically located at the edge of cities or within agglomerations, have an important function in passenger travel above a threshold distance which, depending on travelling times on ground and on relative price structures of competing modes, may be of the order of a few hundred kilometres. While in more central parts of the EU, gateway functions correspond with big hub airports in metropolitan areas, in peripheral regions much smaller airports become the main pillars for accessibility. The hierarchic order of hubs and regional airports normally reflects the size, the geographical location and the economic importance of the corresponding city, although this can sometimes be affected by the marketing activity of an individual airline. To optimize sustainability of mobility chains, major airports should be linked to the railway network, in accordance with their individual catchment areas and the corresponding traffic demand.

As the bridgeheads of ferry connections, seaports may also have an essential function in passenger transport.

In freight transport, apart from the connection points to land transport corridors beyond the Community, mainly to the East and Southeast, it is the seaports which play the most important role, whether as gateways connecting the EU with major economic regions overseas, or providing the connections to short sea shipping, "Motorways of the Sea" and, in some cases, to the inland waterway network, as an alternative to congested land-based links.

In parallel, air freight is a fast growing segment, although still at fairly low overall volumes. Although it is an important determinant for the equipment of airports, it has so far had little impact on the network as a whole, because in almost all cases land transport is carried out on (existing) roads. Proposals for rail freight links are however being developed and this may change the situation.

4.2.2. The Links of the Core Network

As regards links, this network planning methodology is primarily applicable to road and rail. Inland waterways are represented by existing navigable rivers and canals, with only a few new links appearing realistically possible, and are thus not subject to the same network shaping criteria as road and rail. This does not preclude the upgrading of existing inland waterways or even, in certain cases, the addition of new links, in order to improve the spatial coverage, the inter-connectivity and the capacity of the European inland waterway system.

The links of the Core Network have the highest strategic importance for long-distance transport and for overcoming spatial constraints, in particular natural barriers and political borders, thereby contributing to a more homogenous and balanced accessibility structure.

They should connect the main nodes, in particular "neighbouring" main nodes, thus adding up along the same orientation to stretched polygonal chains, which connect even more distant nodes. Should the resulting detours cause traffic in relevant relations not to follow these links or lead to overlaps with other axes and bottlenecks, the addition of direct links to more distant nodes may be considered. All these chains of links, which form corridors, together with the corresponding nodes, add up in their totality to the Core Network.

While acceding countries and the Western Balkans shall be included into network planning as if they were already members, land-based connections to the outside world shall be provided as well, in particular towards Eastern Europe, Asia and Northern Africa. Therefore, the Core Network has to be linked with the main axes to these regions, as identified in 2007 and partly further developed in the regions of the Northern Dimension, the Central Axis, TRACECA, etc.

To enhance the overall effectiveness of the network, the alignment of links should normally be as direct and straight as possible, with smaller detours to include intermediate nodes. Alignments should however follow, as far as possible, infrastructure that already exists, is under construction or is planned, to allow bundling of flows or to bypass unavoidable natural obstacles, settlement areas and ecologically sensitive spaces. In order to optimise overall efficiency and sustainability, network density can be reduced by such bundling of traffic flows wherever possible, taking into account geographical conditions, users' needs, and capacity constraints.

Detours may be justified in order to integrate into a link additional nodes such as smaller cities, airports, etc., if not too distant from the direct line and if the disadvantages due to additional distances or travelling time do not exceed the benefits of improved regional or local accessibility, and/or of bypassing protected areas, taking into account any additional traffic demand induced by the additional node.

However, detours which are not justified by benefits which are greater than corresponding disadvantages should be avoided or even be removed by shortcuts, if the traffic effectiveness of a corridor and/or cohesion is seriously affected by existing detours because of "missing links". With a view to ensuring sustainability, the goal should be not only to maximise traffic effectiveness, but also to minimise environmental impact including pollution and CO_2 emissions.

On rail in particular, and based on case-to-case considerations, corridors may be split into parallel branches if justified by geographical conditions, traffic demand, different technical parameters and operational issues or to serve regions with differing spatial or economic structures and affinities for passenger and freight. This would allow the separation of traffic flows with radically different characteristics, such as high speed passenger and heavy haul freight, allowing better exploitation of capacities. However, creating Europe-wide networks dedicated exclusively to passengers or freight does not seem a realistic option.

The Core Network shall include the "Motorways of the Sea", which are one of the existing priority projects, adapted as necessary to future needs. On the basis of real or potential traffic flows, they shall connect ports which have been identified as main nodes of the core network and continue land-borne links across the sea. This is of particular importance for insular Member States, which should be connected with the continental part of the Union by appropriate "Motorways of the Sea" links. Furthermore, "Motorways of the Sea", as maritime shortcuts connecting peninsulas, should offer a more efficient and sustainable transport alternative by avoiding detours around bays.

4.2.3. Capacity Needs and Technical Parameters

At present, the 2008/2009 economic downturn makes it impossible to establish reliable traffic forecasts, in particular regarding freight transport. It is possible that transport development may never, or only after a very long period, reach the growth curve of the years before. This may be of particular relevance for some projects with a focus on capacity increase and would affect the urgency of their completion, although the creation of future bottlenecks will still need to be avoided. Projects with a focus on quality improvements and the reduction of travelling times for passengers may be less dependent on economic developments.

Whereas the strategic importance at European level of a link is clearly determined by its geographical functionality and the volumes of long distance or international traffic flows, the design of the total capacity of the infrastructure requires overall present and future transport volumes, including regional and local traffic, to be considered.

This differentiation is of particular importance for nodal areas and their surroundings where, in virtually all cases, the share of local and regional traffic far exceeds that of long distance or international traffic.

Technical parameters of network elements, like curve radii, gradient, cross-section (number of lanes or tracks) depend on their intended function and their forecast traffic volumes, taking into account operational aspects or the required level of service and the goal of creating homogeneous conditions along an axis.

5. Assessment Methods

The methodology developed for strategic Core Network planning is based on a set of criteria relating to transport economics, environmental and spatial planning issues. It will be necessary not only to validate this methodology by applying it to concrete examples, but also to assess the impacts of the resulting network variants on spatial structure, on the economy, on the environment and on society. A fuller discussion of alternative methodologies is contained in the annex to this document.

Four alternatives appear to be available for such an assessment:

- cost-benefit analysis (CBA)
- multi-criteria analysis (MCA)
- spatial computed general equilibrium models (SGCE)
- systems-based models (SDM)

Each of these approaches has both advantages and disadvantages, which are set out in detail in the annex. The CBA is more suitable for individual project appraisal rather than network analysis, while the MCA is more adapted to the strategic approach. However, its utility is highly dependent on identifying the correct relative weightings to be attributed to the different criteria. While the more advanced and complex models (SGCE, SDM) address many of these shortcomings, they are highly dependent on the availability of large volumes of data and do not yet appear to be sufficiently developed to be entirely appropriate for this type of exercise.

In these circumstances therefore, a single model, which can deliver all the inputs needed for a comprehensive assessment of Core Networks, does not exist. The dominance or monopoly of one model approach should therefore ideally be avoided and the different focuses and specific features of different assessment methods could generate valuable inputs for the final policy analysis of future options and risks associated with a Core Network design.

At the same time however, there is a recognised need to move ahead with the development of a network design implementing the proposed methodology. In order to test the methodology therefore, consideration might therefore be given to utilising the TRANSTOOLS model, developed by the Commission and currently being used for the establishment of a reference scenario for the upcoming White Paper on Transport and for the impact assessment of the policy packages that will form part of this exercise. TRANSTOOLS has the advantage of explicitly considering transport networks at a relatively detailed level of regional detail and it is currently being utilised for a range of other TEN-T related studies. TRANSTOOLS already uses some elements of SCGE modelling, through the work done by Kiel University (see Annex).

Assessment Methods

While direct economic impacts, like cost savings due to improved operation, can be monetised fairly well and with a high degree of accuracy with existing instruments of ***cost-benefit analysis (CBA)***, it is in the very nature of many important social and environmental impacts that any assignment of a monetised value is, to a certain extent, subject to individual views, experiences and preferences. This applies for instance to travelling time savings, impacts on health or human life, as well as long-term consequences of greenhouse gas emissions, where some arbitrariness in defining monetised unit-values is inevitable, even in a cost-benefit analysis. Finally, it is almost impossible to monetise the effects of spatial integration, accessibility improvement or territorial cohesion on the regional economy, due to improved transport infrastructure, by simple tools like CBA. However, as recent findings of economic geography show, these aspects might in many cases be critically important for structural development.

A classical cost-benefit analysis is an appropriate and recognised tool for the appraisal of individual projects. However, at the strategic level, in order to optimise the overall efficiency of the future Core Network, by comparing shape, density and modal structure of different variants against the relevant objectives laid down in the Treaty, some kind of ***multi-criteria analysis*** seems to be more appropriate.

The advantage of the latter approach is that effects only need to be quantified but not necessarily monetised. It may be regarded as a disadvantage of multi-criteria analysis that scores and weights have to be introduced to map all performance indicators into a common scale. But an appropriate clustering of impacts into economic (monetised), spatial, environmental and social (non-monetised) lead indicators may be sufficient to provide a solid and transparent base for decision making.

More advanced assessment models such as ***spatial computed general equilibrium models*** (SCGE) try to simulate rebound or feedback effects by integrating transport into the context of economic geography, considering spatial heterogeneity (topography, resource distribution, knowledge, competition) and market imperfections within a general equilibrium context.

Their advantage is that (freight) transport is placed at the heart of economic interactions, identifying the benefits derived from the economies of scale achieved by distributing production, sourcing and distribution over space. Better infrastructure, providing higher quality and lower costs, helps to drive and channel spatial economic growth. An outstanding example is the CGE Europe model, developed by Kiel University for the Commission and a component of the comprehensive EC TransTools model. However, SCGE models are very data-extensive, hard to calibrate, static and restricted to a rather limited number of economic sectors. Typically, the impact measurement is performed in monetary terms by an economic welfare indicator. Despite their high level of sophistication SCGEs cannot generate all information needed for the assessment of Core Networks (e.g.: dynamics of technology, environmental impacts). But they can be linked to less complex dynamic simulation tools, such as, for example, systems dynamics, to close such gaps.

Applying a "systems approach" allows transport to be placed into the wider context of economic, social, environmental and spatial interactions. Interconnections and their change over time can be modelled by feedback loops, including technological change (leading to a change of economic structures) or social developments (e.g. the aging of population or migration in space). The indicator system for assessing the state and the change of a system may include indicators from the economic, spatial, social or environmental modules (e.g. GDP, regional development potential, income distribution, GHG emissions).

In particular, ***System Dynamics Modelling*** (SDM) consists of four elements (cybernetics, decision theory, numerical simulation and mental creativity) the latter allowing the insertion of the missing elements to obtain a complete quantitative context of the feedback mechanisms.

The most advanced European model of this kind is SDM ASTRA, which has been developed since the 5th Framework Programme and is being continued within several EU projects (TIPMAC, iTREN). It covers all EU countries plus Norway and Switzerland and consists of eight basic modules covering: population, macro-economy, regional economy, trade, transport, environment, technology and fleet change, appraisal. The modular structure allows for easy integration of further modules.

System approaches can take into account developments of networks in a long-term perspective. Calibration is easier than in SCGEs and the quality of approximation to observed developments can be tested by ex-post forecasting. Furthermore, links can easily be constructed to combine SDM with back-casting procedures, which often are favoured for environmental, land use and strategic action planning. Nevertheless macro-scale SDMs like ASTRA still have some need for improvement, in particular with respect to the modelling of spatial impacts – which is the strength of SCGEs.