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COST350
Integrated Assessment of Environmental Impact of Traffic and Transport Infrastructure
- A Strategic Approach

Part C
Chapter 3
Tools and models overview for analysis and evaluation of the transport-related environmental conditions

INDEX

Overview

In this chapter the main focus is to define the most appropriate transport indicators that can be used for the strategic environmental assessment (SEA) of the transport plans and programmes.

The plans and programmes have implications on the environment that can be measured and analysed in an expedite way by transport indicators related to the environmental key-factors. The ambit of this analysis consists in a first approach to an overview of the macro impacts of the plan, which is mostly adequate for a strategic assessment where to understand the main effects of the transport activities, the trends and the macro impacts of a transport plan is sufficient for the decision-makers to take the most sustainable decisions, above all in situations of lack of time and base information.

To define the aforementioned transport indicators two steps have been followed:

- the first step has been to make the inventory of data and tools used in EU countries for the transport planning, to individuate the available transport parameters that can be used in the plans and programmes evaluation and to understand the degree of detail and the approach adopted in the different countries;
- the second step, based on the information taken from the above inventory, has been to set up a methodology for the definition of an appropriate set of transport indicators that can relate transport and environment. The method chosen to do this approach is based on DPSIR-scheme, mainly in its first two steps: “Driving Force” and “Pressure”, where the other steps of this scheme (State, Impact, Response) are developed in chapter 4 where the environmental indicators that should be used on SEA are described.

1. The inventory of data and tools used in EU countries for the transport planning

A main point to better understand the transport planning in the different European countries is to investigate which kind of data are collected and which tools (models and measurements/surveys) are used to carry out the transport plans. Such an inventory has been done in some of the different countries involved in the COST 350 action “Integrated Assessment of Environmental Impact of Traffic and Transport Infrastructure”.
Eight countries have answered to the questionnaire: Czech Republic, Germany, Hungary, Italy, Portugal, Spain, Netherlands, and Poland. Hereafter, the results from the eight countries afore-mentioned are given.
The information collected through the questionnaire are referred to a specific period of time and, only in some cases, are related to specific case-studies where the plans are not adopted at all the territorial levels or the corridor level is considered. Above all in this last case, the information here reported do not give a general procedure for the country, while they give current general trends for the other mentioned cases and countries.

1.1.1 Planning option level

Concerning the ***“Planning option level”***, a first table can be draft (table 1). The general finding is that the planning option level of the cases presented by the different countries is strategic. The only exception is represented by Spain, where the National Transport Plan is of course strategic, but “in fieri” yet, so that the case considered in the questionnaire is the Corridor, planned at tactical level.
The choice for Spain is due to the fact that no models are used in Spain at strategic level. The information provided in the questionnaire comes from “informative studies” statutorily carried out in accordance with provisions contained in the EIA directive as transposed to the Spanish legislation. Most of the informative studies surveyed refer to road corridors. The scale of data collection varies according to the different phases of the study.
An interesting remark is that, nevertheless the planning option level is different, the data collected and the models used in Spain and in the other countries are very similar, and so the level of detail is quite the same. This can spur a further consideration about the tools used that, being the same at the different levels, create a contradiction with the concept of the different approach needed for the different levels: macro and micro, less and more detailed going from the highest to the lowest geographical level and from strategic to tactical planning level.

Table 1 – Planning option level: state of the art in the six countries

	Czech Republic	*Germany*	*Hungary*	*Italy*	*Portugal*	*Spain*	*Netherlands*	*Poland*
Planning option level								
1a: Strategic	X	X	X	X	X		X	X
1b: Tactical						X		
2a: National		X	X*	X	X		X	X
2b: Regional	X		X	X	X°		X	X
2c: Local			X*		X			
2d: Corridor	X		X		X	X	X	X

* based on new SEA Governmental order 2/2005 (I.11.)
° there are several regional plans, but until now they have not submitted to SEA

A risk arises from such a situation when the environmental concern becomes the main element as in SEA. The risk is that the EIA approach is followed as the detail of transport data spur the use of the well-known models/tools to calculate the most known impacts from transport systems as air pollution and noise.

Then, the questionnaire is divided in two sections: “mobility” and “land use and environment”. Concerning the ***“Mobility section”*** the typology of the tools adopted in term of measurements, models and data bases is investigated to see the similarities and differences between the different countries, but, above all, the current level of detail adopted in transport planning.
The section ***“Land use and environment”*** wants to investigate if there are some interactions in the plans and programmes with the land use and the environment. This helps in the understanding of the current trend in considering the environmental concern in the transport planning and the way in which it has managed.

1.1.2 Mobility section: findings

The actors of the data collection (measurements and surveys), in all the countries investigated, are state-based bodies - the Ministry of Transport, Regions, Provinces, Municipalities, Road Administration, etc. – helped, under the operating side, by private consultants who carry out above all the surveys.
The geographical cover of the data depends on the planning option level.
In the national plans (Germany, Italy, Portugal) the area of interest of the measurements and surveys is the national territory, with focus on the all national infrastructures (roads, railways, waterways, harbour, airports) for Germany and Italy, while mainly on the roads for Portugal.
In the case of Czech Republic, Hungary and Spain the measurements were focused on corridors with attention to the project level. In Hungary, now SEA is obligatory at road network planning on national and local level, on other level it is mandatory (depending on the importance of environmental impacts).
The ***kind of data*** collected thanks to the ***measurements***, on the *demand side*, are:

- ➢ for private transport:
  - traffic volumes (average daily traffic and hourly traffic – peak hour);
  - vehicle typology (cars, trucks, etc.);
  - car occupancy rates;
  - speed;
  - travel times;
- ➢ for public transport:
  - traffic volumes (passengers per day on the lines);
  - vehicle speed (average and maximum).

On the *supply side* the data collected by the measurements are:

- ➢ for private transport:
  - geometric characteristics of the infrastructures;
  - design speed.
- ➢ for public transport:
  - kilometres travelled, number of vehicles per day, frequency;
  - commercial speed;

Not any data on public transport are collected, now, in Portugal. In Czech Republic, the association of the urban public transport publishes the yearbook containing the numbers of carried persons, public transport performances (passengers*km).
The ***kind of data*** collected by the ***surveys***, on the *demand side*, are, for private and public transport:

- O/D matrix;
- travel costs;
- travel times;

The kind of survey used are census, and sample survey based on RP and SP (for the prediction) and contingent valuation.
These data should help in the definition of a data base, basic information for the fruitful use of the transport models.
The ***data bases*** are generally built by the public authorities helped by consultants in the operating data collection (see measurements and surveys).

The most complete data bases are that built on the National Travel Survey (NTS) that many countries carry out on a regular basis. Another source of transport data, built on a regular basis, is the national population census (generally every ten years).
The most important difference on the demand side, among the surveyed countries, is the presence or not of the NTS. Italy and Spain have not a NTS, so that the data are collected not on a regular basis and do not cover all the territory. Measurements and surveys are carried out in precise circumstances as making or updating the plans (national, regional, corridor) on a sampling basis.
Germany provides a traffic census every five years, Hungary has a traffic data bank for the national roads and O/D data on different levels (national, regional, local), Portugal provides a data base on national level with a zoning system, Czech Republic gives the traffic volumes on the national roads.
The *data contained in the data bases* are that collected during the measurements and surveys:

- traffic volumes (with vehicle classification);
- O/D matrix;
- average speed.

On the supply-side, a national road databank is generally available containing the geometric characteristics of the infrastructures, the road capacity and level of service. Data on accidents are also collected in Hungary (national road accident databank). In Italy there data on accidents, but are not formalized in a data bank.
The ***models*** used in the different countries are some of the well known four step models available on the market, having, thus, the same approach. They need more or less of the same data of input and give the same data of output.
EMME2 is the most widely used model while Germany (and Italy for the next national plan update) uses VISUM. In some cases national models are used (as MT for Italy, in the past, and AUTO for Czech Republic).
The input data are, generally:

- nodes and links of the network;
- link characteristics: length, number of lanes, design speed, capacity, level of service, travel time and operational costs, etc.);
- O/D matrix;
- volume-delay functions;
- turn penalty functions;
- traffic observed volumes (average annual daily traffic)
- socio-economic data.

The output data are:

- annual average daily traffic or hourly traffic (peak hour) on the network by typology (private and public transport);
- travel times and speeds.

Restraints, limits and reliability
The main limits regarding measurements and surveys are quite "physiological" as they are due to the number of sampling points and the number of the interviewed people and the reliability of the answers.
When there is not a NTS, a problem is due to budgetary and administrative constraints so that limited ad hoc survey can be carried out. In Germany and Czech Republic, generally, the roads inside the towns are not considered. In Hungary, detailed data bases regarding transport and environment are available, but, as the problem can be considered SEA "technology", method, evaluation and calculation, therefore there are not so many experiences as regarding the EIA.
Concerning the models, their reliability is of course linked to the input data. Hungary declares a limit of accuracy depending on different factors as economical and political situation.
Nevertheless a general reliability is declared for the mobility data and tools.

1.1.3 Land use and environment section: findings

In all the interviewed countries an interaction both with land use and the environment is declared.

1.1.3.1 Land use

In *Germany*, the interaction with the land use is based on the spatial impact assessment.

In *Spain* land use and transportation models are sometimes used to establish future demand and relevant data used as input to models. During the informative studies existing land use and other territorial plans are statutorily examined. Land set aside for specific uses or banned from development is designated by municipal zoning plans and also by relevant agencies (agriculture, environment, etc.) at national and regional levels.

In *Czech Republic* the land use changes are inputs for the calculation of new trip numbers, which depend on the type of land use (i.e. residential area, service area, public green space, playgrounds, offices, etc.).

In *Italy* macroeconomics and socio-demographic scenarios are provided only for long-term forecasts, and residential and activities' locations are considered in the definition of transport demand.

Very different are the bodies who carry out the data collection.

Concerning the ***measurements***, except Germany, where none measurements are carried out for the spatial impact assessment, in the other cases bodies at different geographical level play a role:

- for Portugal, the Portuguese Road Institute (for the regional plan of the Alto Minho Region and for environmental studies at corridor level);
- for Czech Republic, the city authorities;
- for Spain, the municipalities or regions as the land use measurements are included in the municipal plans, in the corridor studies, and in the regional plans;
- in Hungary, the Soil Protection Office and the Directorates of the National Parks;
- in Italy, the data comes from municipalities, provinces, regions.

These data are more "local" than the transport data as, generally, local bodies collect the information and the data are more used at project level. Data on land use are also given by the National Statistical Offices who put together the local data to give a national vision on land use.

The kind of measurements on and use concern with the inventory of:

- the population and its density;
- commercial and industrial units and their density;
- cultural and historical places.

In Hungary these data are published and most of them are updated on a yearly basis.

Concerning the ***surveys***, the same approach of the measurements is found. The surveys are often at project level (Germany) or concern the cities and the landscape outside the cities (Czech Republic), and, anyway, are quite specific. They are carried out by the municipal authorities/cities and/or their consultants. In Hungary a wider range of surveyors are involved as different State and Private Companies, private experts in commission of Ministry of Economics and Transport, Environment and Water Management, National Motorway Agency, City or Local Municipalities, State Public Road Administration Public Utility Companies, State Railway Company etc..

The surveys concern the value of landscape, the economical land value, the cultural heritage, the significant landscape elements. In Germany the focus is on the definition of the importance of the cities in term of regional planning and on long-distance motorway with high traffic density.

All these data form the ***data bases*** that are carried out by federal or administrative authorities, at local, regional, and national level.

Thus, there are authorities that manage the land use data and collect them in data bases, available at different geographical levels and joined to the data obtained by the census.

The ***models*** are not used for the land use, but tools to represent and/or evaluate the land use are considered. The most used tools are the Geographical Information Systems (GIS) or simply the maps. In Czech Republic a methodology is available to evaluate the character of landscape and its enforcing in the Public Administration. The input data of the mentioned tools are that provided by measurements and surveys, focused to describe the socio-economical aspects (population, activities, etc.), the landscape, the protected areas … finally, the land use.

Restraints, limits and reliability

The restraints provided concern only with the sensitive areas which extension can be expected due to further measurements (Hungary). Thus some data bases are not relevant because the limited surveyed area and the scarce data updating.
In Hungary, the Government has proclaimed the Natura 2000 network and maps about these protected areas are now available. At strategic level, evaluation of the maps (GIS) and consultations with Directorates of the National Parks seem to be enough.
In Czech republic the major limit envisaged is that the methodology to evaluate the landscape is used either at EIA or SEA level.
The general limit envisaged is the subjectivity of the tools due to the evaluator interpretation/perception. In addition, the different sources of information (Spain and Italy) in term of body (and so geographical level) and time (collection and updating) and the ad hoc measurements/surveys to complete the data make less reliable the information obtained.

1.1.3.2 Environment

In term of the interaction with the environment, the most important thing is that the transport data are the input for the environmental assessment, using models. On the other hands measurements and survey are carried out on the environment so that many descriptive data on the state of environment are available in the different countries.
Also in this case, the measurements and surveys are carried out by public and private bodies and are focused at project level in most cases. Concerning the measurements using fixed or mobile measurement stations, all the territory is covered in Czech Republic. In Italy a network of air pollution stations is managed at regional level by ARPA (Regional Environmental Protection Agency), coordinated by ANPA (National Environmental Protection Agency) at national level. In Spain the ministries (development, agriculture and environment) with the regional agencies and municipalities carry out measurements and surveys. In Portugal is always the Portuguese Road Institute (for the Alto Minho Region case and for environmental studies at corridor level) that do the measurements and in Germany the consultants collect the data. In Hungary a lot of organisms are involved: ministries, agencies, municipalities, Road and Railway companies, consultants.
The ***measurements*** concern mainly with noise and air pollution and consists in:

1. for noise:
   a. measuring noise to have an acoustical monitoring and expressing it through the noise indicator as Leq_d, Leq_n, Leq_{den};
   b. measuring main air pollutants (CO, NO_x, VOC, SO_2, CO_2, benzene, PM_{10}, O_3, etc.) concentrations by the air pollution stations;

The ***surveys*** investigate mainly the exposure of the population to the transport pollution and regard:

- the noise exposure evaluated through the calculation of the number of inhabitants exposed to noise levels over the limits;
- air pollution exposure evaluated through the calculation of the number of inhabitants exposed to high values of concentrations (mainly in the urban areas).

The surveys regard also the exposition of fauna and flora to the pollutants with major attention to the protected areas and the problem of habitat fragmentation due to the infrastructures.
Another typology of survey is concerned with the valuation of the costs to reduce the noise pollution (e.g. noise barriers).
Other data collected through the measurements are that on water and soil quality.

The ***data bases*** are built by the same bodies involved in the measurements and surveys and are managed by the public authorities. The area of interest is the national territory with main focus on polluted and noisy areas at regional or local level. The data bases typology envisaged are:

- national and regional air pollution emissions (Hungary, Czech Republic, Portugal);
- local and regional air pollution immissions (Hungary, Czech Republic);
- national air quality data base (Portugal);
- noise immissions, noise maps of some cities or along infrastructures (Hungary, Italy);
- fauna passage data base (Czech Republic);
- protected areas data base (Germany and also other countries);
- atlas of designated areas and cultural resources relevant for corridors in national roads (Spain and Portugal)
- data base of protected flora and fauna (partly is available) (Hungary and Portugal)
- water quality data base for rivers and lakes (Hungary, Portugal);
- soil quality data base (Hungary);
- climate data (Portugal).

The use of the ***models*** to forecast the environmental impacts is a common approach in the different countries. The models are used to do the inventory of air pollutant emissions and to provide the noise levels. In some cases also the dispersion models are used, but at project level.

Concerning the emissions the following models are used:

- COPERT 3 (Computer Programme to Calculate Emissions form Road Transport);
- CORINAIR (total national emission for European countries);
- Hungarian national, regional, local emission models (survey) for whole transport sector (road, rail, water, air);
- EU project "ARTEMIS" is preparing a detailed emission model for EU countries;

Concerning the air pollutants concentrations the dispersion models are used:

- 3-dimensional micro-scale non-hydrostatic flow and dispersion model MISCAM (Germany);
- the dispersion models: the gaussian model Symos, the model assessing air quality in street canyons AEOLIUS, ATEM (Czech Republic);
- simple models as MluS-92, MluS-96, SRI-92P, IMMIS-Luft, Car International. Immprog98, HIWAY (Hungary);
- models demanding detailed input data: KFZ.LAG, CFB, MISCAM, WINMISCAM, MUKLIMO, DASIM, ABC, PROKAS, ROADAIR, etc. (Hungary);
- the Hungarian transmission standards, used for different purposes (EIA, etc.)

Concerning noise the most well known models are used as MITHRA, SOUNDPLAN, PREDICTOR, LIMA, CADN-A, RLS-90 to build the noise maps.

In Hungary, the calculation of the noise due to the traffic flow in relation to public roads is made on the basis of the amended version of the Road Technical Rules Ut 2-1.302:2000 "Calculation of the noise of public road transport". The calculation of noise propagation is made in accordance with the standard MSZ 15036:2002.

The *input data* of the models are mainly the transport data which are very detailed to be used in these models.

For the emission models, the input data are:

- vehicle fleet, number of vehicles classified in the different categories (passenger cars, light and heavy duty vehicles, motorcycles, buses, coaches) and different types (year of manufactures, fuels: diesel, gasoline, 2-stroke engines, 4-stroke-engines, engine powers) etc.;
- annual mileage per vehicle;
- mileage distribution (urban, rural, highway);
- average vehicle speed;
- monthly ambient temperatures;

For the dispersion models, the input data are:

- meteorological data;
- wind speed and direction;
- geometric characteristics of the infrastructure;

- characterization of the surroundings;
- emission factors.

For the noise models, the input data are:
- number of vehicles classified by categories;
- vehicle speed;
- road surface typology;
- geometrics characteristics of the infrastructure;
- characteristics of the surroundings (buildings, topography, etc.);
- distance correction (geometrical divergence/spreading);
- atmospheric sound absorption;
- ground effect;
- attenuating effect of the vegetation and buildings;
- sound screening;
- sound reflection.

The *output data* of the models are:

1. for the emission models:
   a. emission factors for the main pollutants: NO_x, NO_2, NH_3, PM, VOC, CO, CO_2, Pb expressed in g/km or g/h;
   b. the inventory of the emissions of the same pollutants applying the traffic flow (quantity, typology and mileage);
2. for the dispersion models:
   a. concentrations for the main pollutants: NO_x, NO_2, NH_3, PM, VOC, CO, CO_2, Pb expressed in $\mu g/m^3$;
3. for the noise models:
   a. the noise indicators: Leq_d, Leq_n, Leq_{den};
   b. the number of people exposed to the different noise levels.

Restraints, limits and reliability

The major concern about the measurements and survey is the not good cover of the territory and that permanent monitoring systems are only provided for the big cities or protected areas. In addition, the update of the data is not regular.

The reliability of the impact assessment through the use of the models is focused on the transport data reliability used as input data in the environmental models. Some hypothesis on the detailed information requested by emission models are done as the transport models do not enter in such a detail (e.g. vehicle classification by construction year, fuel, engine displacement).

Then the external costs are not considered, but only the environmental risks and benefit components.

1.1.4 Conclusive remarks

The current transport planning in the different European interviewed countries shows a certain degree of complexity due to the quite sophisticated models used and requires a continuous monitoring to collect the needed data.

This situation has leaded to have a large quantity of data (also if not always complete at the different geographical levels) and, hence, to build national/regional/local data bases spurred by the need to know deeply the transport, land use and environment state of the art. The planning has to be based on a well-know current scenario to provide sustainable scenarios for the future.

If this approach can be good at project level, it becomes more and more complex when the planning level is strategic and cover higher geographical levels (as national).

The current situation in assessing the transport infrastructures is focused on detailed studies that allow for a cost-benefit analysis as final tool for the decision makers, and this evaluation is the EIA.

Where some attempts have been done to evaluate plans, the same approach used to evaluate single infrastructures/projects seems to be followed, so that the SEA becomes an EIA. The available data and models permit this trade-off where the difference is the

application of the tools at higher geographical level (e.g. an entire nation) and implies simply a stronger calculation power.
If we agree that the strategic approach cannot enter in a great detail, we do not need of all the data currently available, but we have to choose the most strategic transport data allowing to understand the trends as car ownership, kilometres travelled on yearly basis, the characteristics of the supply and its trend (increase or decrease) in respect to the demand.
Also the observation of the monitored data after the implementation of plans and programmes is important to correlate these ones with the environmental data obtained by the monitoring.
A more qualitative approach leading to a transport and environmental balance could be more useful than long and detailed calculations.

1.2 The selection of transport parameter assessment methods

The selection of the best tools is the most delicate part because their ability to consider the interaction with environmental aspects (e.g. air pollution, noise, aesthetics, etc.), land use aspects (settling down of activities), technological aspects (ITS, vehicle technology, etc.), political choices (pricing policies, taxation, etc.) is a guarantee for the tool reliability in the forecast and the support to decisions.

As the characterization of the environmental impacts passes through their quantification by the way of the indicators, it is necessary to individuate:

- the transport variables needed to quantify the impact (kind of data, data bases, etc.);
- the tools most suited to quantify the impacts; here the inventory of the models (see above) has been fundamental, focusing the attention on the models used to forecast and simulate the travels and on the integration efforts made to join transport models to environmental one (emission and dispersion models, noise models, etc.), and on the Geographical Information System (GIS) to manage the data and results.

The difficulty to have a reliable calculation of the environmental impacts, due to the lack of the transport models to give the precise and detailed data necessary to the environmental models, is depicted in table 2 where it is clear the difficulty in joining transport models and environmental models (in this case, emission models) given the different level of details obtained and requested by the two types of models.

An example of an overview of potential near-term enhancements to current transport analysis framework is given in figure 1.

In spite of the critical considerations concerning the models' reliability, the current assessment methods of transport parameters are that reviewed in the section 4.1. The four stage transport models are currently used, joined to measurements and surveys, to define the main transport parameters dealt with the plans: that is traffic volumes, speed, km travelled.

1.2.1 Findings on parameters and methods suitable to carry out a SEA

At this point, given such preliminary remarks, *two routes are possible* to be followed in a SEA approach:

1. *an EIA-oriented approach*. This means to use the current available transport data and the transport models to give the input data to the environmental models, as depicted in figure 2. This methodology, proposed for the National Transport Plan in Italy is very similar to the practice followed in the surveyed countries where the same data are collected, supply and demand models are used and the same output data are given.

   This approach requests detailed data which are, anyway, available due to the monitoring carried out in almost all the European countries, also if the data do not well cover all the territory and, sometimes, the different sources of information in term of body (and so geographical level) and time (collection and updating) and the "ad hoc" measurements/surveys to complete the data make less reliable the information obtained.

Table 2 : Output and input data of transport and emission models

TRANSPORT	MODELS		EMISSIONS MODELS
Type	**Output data**	**Type**	**Input data**
Econometric	VMT (vehicle miles travelled)	**Average**	type of vehicle classified by type/road/pollutant
	n° cars		average speed per vehicle type and road
			VMT per vehicle type and road
Travel demand	n° trips per mode from O/D		average trip length
	Link flows		ambient temperature
	Link speeds		fuel volatility
	O/D travel costs		ambient temperature at start
	VMT = length link * volume		average speed in transient
			parking conditions
Simulation	vehicle speed at spec. location		use of heating system
	moving delay		wind speed
	static delay		engine thermal status during trip
	% traffic in weaving mode		engine thermal status at the end of trip
	intersection delay		
	ramp delay	**Modal**	speed profile
	progression effectiveness		speeds and accelerations
	signal effectiveness		
	signal effectiveness		
	volume to capacity ratio		
	level of service		
	speed-time profile		

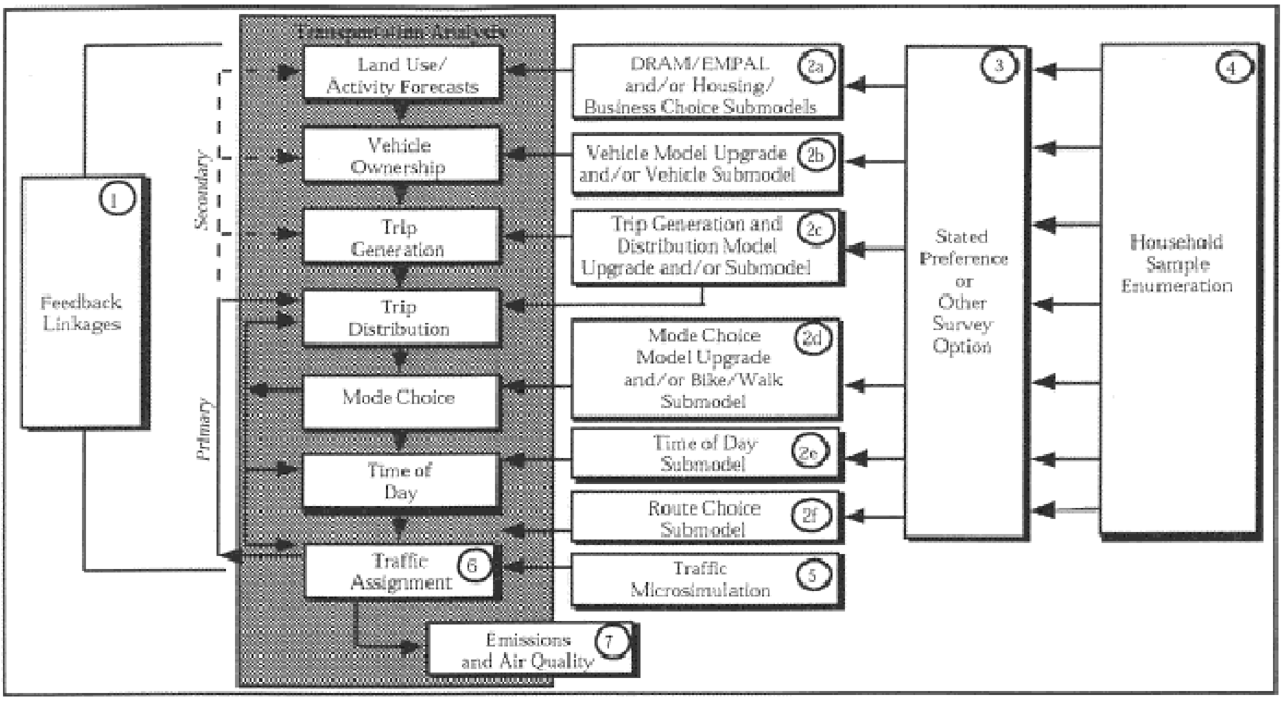

Figure 1 – Overview of potential near-term enhancements to current transport analysis framework

This is, of course, the easiest way to carry out a SEA, nothing has to be invented and all the information, nevertheless the limits and weakness that the research has to solve yet (figure 1), are available. The right trend, which the EU countries are following, of a continuous monitoring facilitates the described approach because the SEA can be a part in the simulation process of planning where the iterative process is provided.

In this case the work is easy and is based on an accurate analysis of which kind of measurements, surveys an data bases are the most appropriate in term of the method followed, choosing the best methods used in the different countries or a mix of them. Then, a similar choice for the transport models and environmental models will be done, where some European directives exist already (see the noise models suggested for the noise monitoring plans).This means that the SEA should simply be put formally into the planning process, becoming the part dedicated to the calculation of the environmental impacts (e.g. see in the figure 2 the box “Emission models and accidents” that give the results in term of data “Emissions and accidents”.

2. *a more strategy-oriented approach*, where the approach of the point 1 above could be overcome thanks to the strategic approach that should characterise the SEA. This implies that WP3 and WP4 should give indications how the current approach (more EIA oriented) could be modified focusing on the SEA of transport planning selecting or defining new data and indicators useful to individuate the trends of the effects due to the transport planning.

1.3 Proposal for a set of transport indicators in the SEA context

To reach the objective of a SEA that is really a strategic tool to evaluate the effect of transport plans, programmes and policies (plans and programmes) on the environment, the definition of a ***set of transport indicators*** is crucial because these indicators could assume the "role" of tools to evaluate the environmental effects of a plan becoming "proxy" variables for the environmental assessment of the transport plans and programmes effects.

To define which transport indicators are suitable to evaluate the effects of the transport plans and programmes it is fundamental to individuate some main criteria helping in the choice of the most appropriate indicators.

The indicators proposed should to be simply computable and should to allow the definition of the trends due to the transport planning and policies adopted. In this way it is possible to compare the indicators calculated per each year and monitor the effects of the plan. Before to propose a list of criteria, some specification on what is an indicator and its characteristics have to be given.

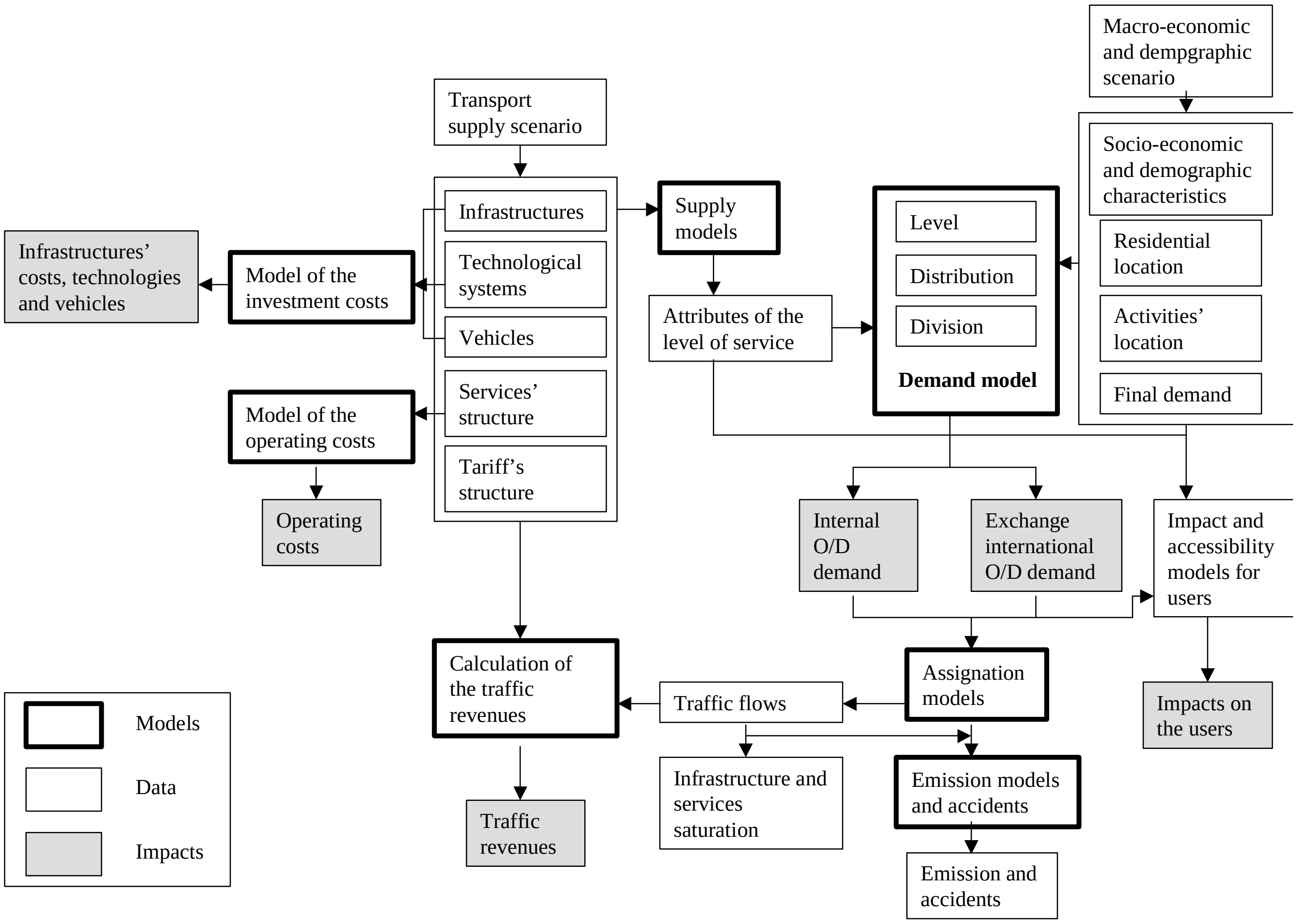

Figure 2 – Functional architecture of the methodological approach in transport planning in Italy

1.3.1. What is a transport indicator

The concept of *indicator* belongs to the ecology and was born from the need to evaluate, in a direct way, the degree of perturbation of an environmental system, due to a certain cause, through the behaviour of biotic species more or less sensible. From this point, the concept of indicator has been exported in every field involving any planning and managerial activity: productive activities, social problems, land use management, etc.

An indicator can be defined as the basic instrument to synthesize the information to evaluate a system. Thus, the research on indicators comes of the need to translate in a simple and immediate way, through a number, a word or a graphic sign, complex phenomena characterized by different types of data, in a continuous process of aggregation and disaggregation of the information.

We have to consider that indicators and indexes (further aggregation of indicators) represents an empirical model of the reality, which assumes that a complex phenomenon can be depicted by a limited set of variables. In the decision-making process, the choice of the indicators is mainly determined by two very practical factors:
- the objectives of the decision;
- the type of available data and information.

When an effective set of indicators has to be defined, the most common problems are:
- the choice of the indicators to be used. These are the main problems in the individuation of an indicator:
  - *lack of the data*;
  - *not homogeneity of the measured data* as: availability of the data only for certain years, lack of availability of the data at a suitable level of disaggregation, measurement of the same indicators by different bodies or on different years using different methodologies;
  - *availability*: often the data are little accessible due to bureaucratic difficulties or because the owner does not want to make them public;
  - *reliability and validity of the obtained data* (human error in copying, analytical error in their determination);
- the definition of standardized methodologies allowing the comparison along the time and between different locations. This is the most delicate point of all the system because excellent indicators can result not effective due to a wrong methodology or bad indicators can be justified in a false representation of the reality. To make easier this delicate process we have to perfectly know every characteristic of the data taken into account;
- the choice of the number of indicators that is sufficient to depict the complexity of a phenomenon and to contain all the information necessary to reach the objectives.

1.3.1.1. Characteristics of the transport indicators

For each indicator we should indicate:
- *descriptive aspects and its relevance in respect to the evaluations done*: explanation of the reasons determining the choice of an indicator for a certain problem; indication of the reference scale of spatial representation;
- *methodological aspects*: description of the unit of measure, method of measure/calculation, frequency of the measurements (and, thus, possibility of updating), availability of data and their source, possibility to forecast the trend through the use of forecast models;
- *interpretative aspects*: representation and analysis of the trend in the time and in the space of the indicator;
- *estimative aspects*: evaluation of the distance from the target; comparison between the values measured in the studied area and the values recorded in other national or international areas.

1.3.2. Set of indicators for the sustainability and conceptual basis

Each body/subject having defined some indicators has classified them in function of their use: thus, we have classifications by matrixes (air, water, soil, etc.), by themes (agriculture, transport, energy, etc.), by categories following Agenda 21 (society, economics, environment, institutions), by way of use (descriptive, performance, effectiveness indicators, etc.), or by section of a certain conceptual model (model PSR – Pressure-State-Response, model DPSIR-Determinant-Pressure-State-Impact-Response, etc.).
In such a way the indicators linked to the development, in these last 15 years, developed by public and private bodies, national and over-national, are in hundreds, also if they are very similar in most cases.

The most important series of indicators we can mention which concern in some way the transport are:

- the indicators from UNCSD (Commission on the sustainable development of the ONU);
- the indicators from EEA (European Environmental Agency);
- the indicators of environmental pressure from Eurostat;
- the environmental indicators from OCSE;
- the ten common European indicators (ECI 10).

We can observe that a big number of indicators currently exist, based on different concepts. In this work we decided to follow the recommendations contained in the SEA European directive (2001/42/EC) and to focus our attention on the selection of indicators useful to a strategic evaluation and more particularly to an integrated assessment of environmental impact of traffic and transport infrastructure. Our objective is to provide a list of few indicators relative to the different impacts categories. This list has to be the shortest as possible and non redundant, and will be divided in two sections of indicators:

- the first section is more transport-related and contains “transport indicators” that are described in this chapter;
- the second section is more environment-related and contains “environmental indicators” that are described in the chapter 4.

To elaborate such a list of indicators we propose to follow a conceptual scheme, as described hereafter and establish a list of criteria useful to the selection of our indicators, explained in the next paragraph.

In ***our context*** the classification system used is based on the conceptual scheme of DPSIR (Driving Forces–Pressure–State–Impact–Response), a revision of the PSR scheme (Pressure–State–Response) proposed by OCSE (fig. 3).

Following the DPSIR, the social and economical development makes a pressure on the environment (generally emissions, wastes) which, as a consequence, changes its state (physical, chemical, biological qualities, etc.) to guarantee the right availability of resources or the biodiversity. This leads to the impacts (on human health, on the ecosystems, on the use and function of the resources) which ask for a response (priorities, reference standards, plans, laws, regulations) from the public authorities which, at their turn, retroact on the determinants (driving forces: economical sectors or human activities as industry, agriculture, commerce, etc.) or directly on the states or on the impacts, through an action of mutual adaptation.

Basing on this scheme, we propose that the environmental indicators have to represent the causal chain linking the human activities to their impacts and to the consequent political answers.

The indicators referring to only one of the elements of the DPSIR scheme are named “descriptive” (so there are descriptive indicators of the determinants, of pressure, of state, of impact and on response). For example, in the sector of the air quality relative to the urban traffic, a descriptive indicator of the determinants can be the number of total circulating vehicles; a descriptive indicator of pressure is the total emission of NOx due to total of circulating vehicles; a descriptive indicator of state is the concentration of NOx in the air; a descriptive indicator of impact can be the frequency of hospitalizations for respiratory pathology; a descriptive indicator of response is the number of days having restrictive measures on traffic. Obviously, the response should retroact on the determinants, the pressures, and the states to improve the impacts.

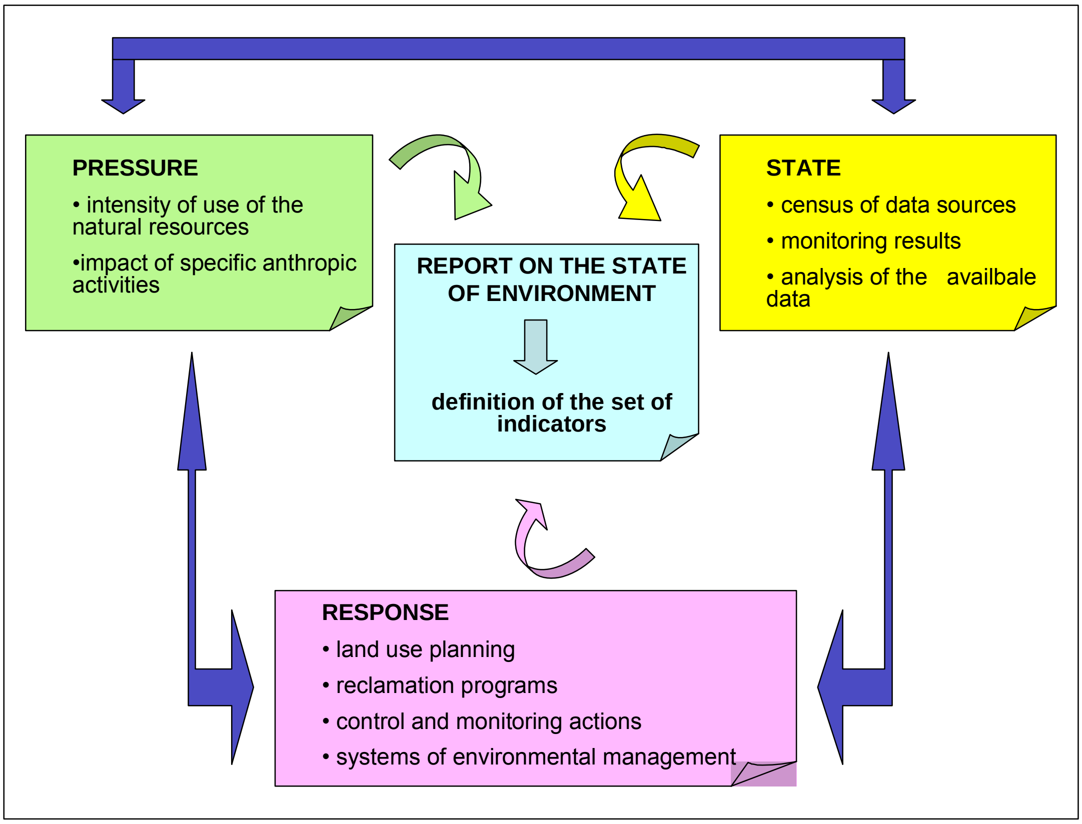

Figure 3 – Scheme of the PSR model (Source: CLEAR, 2001)

1.3.3. A set of criteria to define indicators for transport in the SEA context

In synthesis, basing on the previous paragraphs, we need to define some specific criteria to select the suitable indicators that are valid both for the transport and environmental indicators. These criteria precise what we expect from an indicator for a strategic assessment of transport plans, programmes and policies, as requested from the aforementioned EU directive.

Thus, we propose the following criteria:

1. relevance for the objective of the plan: a strong relationship (direct or indirect) between the indicator and the objective of the plan, in term of environment, has to be envisaged replying to the following questions:
   - how well the indicator follows cover the targets?
   - how good is the indicator to provide a basis for the evaluation of actions and plans?;
2. ability to evaluate the long term effects (impacts) of the plan. The question to be asked for is: how well the indicator give a prognosis ?
3. ability to monitor the effects of the plan, giving the trends and allowing the comparability across the time. The question to be asked for is: how well the indicator performs to provide a basis for comparison across time ?;
4. transferability in the time (different time periods). The question to be asked for is: how well the indicator can be used in different time periods (past, present, short and long term future) ?;
5. transferability in the space (different geographical areas). The question to be asked for is: how well the indicator can be used in different geographical areas maintaining its performance ?
6. usableness at different geographical levels (local, regional, national). The question to be asked for is: how well the indicator can be used in a standardized way at different geographical scales ?;
7. easiness of calculation. The question to be asked for is: how well the indicator can be calculated using easy tools ?

8. easiness of updating. The question to be asked for is: how well the indicator can be calculated, during the updating in the years, using easy tools ?;
9. use of raw data needed to calculate the indicator which are available or obtainable in an easy and not expensive way. The question to be asked for is: how well the indicator can be calculated using simple data that are easily achievable in term of money and time and, above all, that are at a raw level (non elaborated) ?;
10. reliability of the calculation methods used to define the indicator. The question to be asked for is: how well the indicator can be calculated avoiding errors due to the calculation methods. Hence, this means: how much are the methods reliable in avoiding bias ?

Then, defined the criteria, we propose to evaluate them according a scheme where will be the following information:
- name of indicator;
- typology of indicator;
- its observance to the criterium proposed expressed in a scale system (1 = low; 2 = medium; 3 = high). This helps in listing also some indicators which can be considered important, but that not completely satisfy the criterium proposed;
- motivation for the choice of indicator.

1.3.4 A set of indicators for transport in the SEA context

The proposal of indicators passes through two steps:
- the first step is to fill in the table showing the motivation of the choice of the indicators and how they satisfy the aforementioned criteria (table 3);
- the second step is to fill in a table showing, per each indicator, the ambit, the unit of measure, the way to calculate it and the data necessary for the calculation (table 4).

Lets consider now the first step (tab. 3). Here we list the indicators showing:
- the motivation of the choice;
- the ambit more related to the proposed indicator, where the ambits considered are: environment, transport infrastructures, and transport demand;
- how the proposed transport indicators comply with the selected criteria.

We will explain now each indicator, following the scheme above that is synthesized in table 3.

1. Accessibility

To guarantee the accessibility is one of the general objectives of every transport plan, at every geographical level, and it has been the driver of the transport planning policies in a lot of EU countries.

The accessibility has a twofold meaning:
- a "positive" meaning because it guarantees the right of mobility for the users because it allows that they can access to the basic services and, possibly, also in a short time;
- a "negative" meaning when the access to the basic services is provided by cars (private transport) and not by more sustainable transport system.

The world-wide situation is characterized by the urban sprawl, the increase of car ownership, and the concentration of work and shopping in out-of-town locations; these have resulted in continuing increases in journey length for all purposes, but particularly for commuting, and access to basic services is becoming more and more dependent on cars.

Accessibility is a complex notion. 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 consists of different compounds:
- a transport component (travel speeds, travel costs, public transport timetables, etc.);
- a land use component (spatial distribution of demand for activities and supplied destinations);

- a temporal component (availability of activities at different times of the day, week, season, etc.);
- an individual/social component (needs, abilities, opportunities).

The overall experienced accessibility is a function of all these components, which makes it hard to approach accessibility from just one angle.

Thus, the indicator proposed here is a mix obtained from two indicators taken from the transport and environment reporting mechanism (TERM[1]) studied to help to monitor the progress of the EU's transport and environment integration policies. These two indicators are: the indicator number 14, named *"Access to basic services (average journey length)"*[2] and the indicator number 15, named *"Accessibility to basic services and markets by transport mode"*[3] measured by the number of jobs that can be reached within one hour by different modes.

Concerning the indicator number 14, data on average travel distances is very scarce. Data collection for this indicator will have to be set up if the indicator requires updating each year. Another possibility is to update the indicator, following the frequency in which travel surveys are held. No standard data set is available for this indicator and, hence, the reliability, accuracy, robustness are not good; the uncertainty (at data level) is large.

The same remarks are done for the indicator number 15.

Thus, ***we propose the indicator "accessibility" measured as the average journey length for purpose and by mode***. It concerns both the ambits, transport infrastructures and transport demand and it complies well with the selected criteria except for the last four criteria related to the easiness of calculation and updating, the use of raw data simple to obtain and the reliability. As already explained commenting the two TERM indicators from which our indicator comes from, the reason is that this indicator can be calculated through the use of quite complex models that need of a lot of data, scarce and not homogeneous through the EU countries.

2. Level of Service (LOS)

The quality of service requires quantitative measures to characterize operational conditions within a traffic stream. Level of service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.

Six LOS are defined for each type of facility that has analysis procedures available. Letters designate each level, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each level of service represents a range of operating conditions and the driver's perception of those conditions.

The analytical methods used to calculate the LOS and proposed by the Highway Capacity Manual 2000 (HCM 2000)[4] attempt to establish or predict the maximum flow rate for various facilities at each level of service—except for LOS F, for which the flows are unstable or the vehicle delay is high.

Many of the procedures in the HCM 2000 provide a formula or simple tabular or graphic presentations for a set of specified standard conditions, which must be adjusted to account for prevailing conditions that do not match. The standard conditions so defined are termed base conditions that assume good weather, good pavement conditions, users familiar with the facility, and no impediments to traffic flow. Prevailing conditions are generally categorized as roadway (include geometric and other elements), traffic (include vehicle type and lane or directional distribution), or control (the type of control in use, signal phasing, allocation of green time, cycle length, and the relationship with adjacent control measures affect operations).

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[1] http://themes.eea.eu.int/Sectors_and_activities/transport/indicators

[2] http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/spatial/TERM14%2C2001/Access_to_basic_services.pdf

[3] http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/spatial/TERM15%2C2003.10/TERM2003_15_Accessibility_to_basic_services_and_markets_by_mode_of_transport.pdf

[4] Transportation Research Board, 2000. Highway Capacity Manual 2000, National Academy of Sciences. Washington, DC, USA

The level of service of the a infrastructure gives clear indications on the traffic volumes, speed, congestion and comfort, and, consequently, is a proxy for the evaluation of pollutant emissions and noise.
It concerns both the ambits, transport infrastructures and transport demand, and complies well with most of the criteria, except the last four ones. The reason of such a low compliance is due to the difficulty in obtaining the necessary data for the calculation, passing through experimental data or models.

3. *Rate (%) cycle paths surface/roads surface*

It gives indications about the “direction” of the plan in term of favouring the less pollutant transport modes. The rate of cycle paths surface on roads surface well represents the proportion of land use dedicated to a sustainable mode as bicycle in respect to the a pollutant mode as road transport. The ambit involved by this indicator is transport infrastructures. This indicator well complies will all the criteria and is very simple to be obtained giving immediately the trend of a transport plan.

4. *Rate (%) reserved roadway surface/plan area surface*

It gives indications about the rate of area reserved for transport in respect to the area available for all the other human activities. Here the indicator expresses how much the road transport infrastructures impact of the land use in a very simple way and using elementary data easily obtainable in case of existing infrastructures and easily foreseeable in case of future infrastructures. The ambit concerned is the transport infrastructures.

5. *Rate (%) surface for public transport / reserved roadway surface*

It gives indications, as the indicator n° 3, about the “direction” of the plan in term of favouring the less pollutant transport modes. Here the emphasis is on the public transport that is an alternative to the private transport, above for the medium-long distances where the less pollutant modes, as bicycle and by foot, are not competitive. This indicator complies very well with all the criteria and the ambit concerned is the transport infrastructures.

6. *Network extension (km) of public transport lines*

As the previous indicator, this one concerns the public transport and expresses the will of solving the disequilibrium between private and public transport evaluating the length of the network dedicated to the last one. In addition, it gives “direction” of the plan in term of favouring the less pollutant transport modes. The ambit involved is the transport infrastructures. The compliance with the criteria is optimal and this indicator is very proper in the monitoring because indicates if a plan is going towards a more or less sustainable concept of mobility.

7. *Rate (%) number of interchange parking places/parking places*

This indicator expresses the trend of a plan in favouring the intermodality because it shows how much a plan provides interchange parking spurring the interchange between private and public transport. The ambit concerned is the transport infrastructures. The simplicity of the indicator and the perfect compliance with the criteria makes it very usable in understanding the effects of the plans and programmes.

8. *Roads Length (km) inside ecologically rich areas (Natura 2000, National Parks, etc.)*

The length of roads inside designated areas expresses the pressure caused by the infrastructures on the environment. If a plan is sustainable this length should be minimized as much as possible (or avoided, if possible); for example, in ecological rich areas, this indicator enables to establish a correlation with the barrier-effect inside the sensible areas and it allows to understand how much of the area is being fragmentised in addition to other projects or occupancy. The compliance with the criteria is excellent and the easiness of calculation is self-explaining, both if the infrastructures are already existing and not yet constructed. The ambits involved by this indicator are the transport infrastructures and the environment.

9. Changes of the land use value

The use of the territory is very important to understand the trend of a country in term of sustainability. The plans and programmes induce important changes in the land use and, for the decision-makers, is useful to have the evidence of their consequences on the territory and, hence, on the population.
As the value of the different areas is well known in function of the activities present in them and these information are given by the real estate market, this indicator allows for the quantification of the loss of value of important and/or pre-established land uses. The indicator is calculated through the quantification of the area before and after the construction of the infrastructure and the relative value (before and after the intervention, as follows:

*Value (€/m^2) of the area before the infrastructures * the area surface (m^2)*
– (minus)
*the weighted value (€/m^2) of the areas composing the new scenario after the construction of the infrastructures * the sum of the areas' surface (m^2)*

In this way is immediate to quantify the change in the land value due to the intervention proposed by plans and programmes and verify if these ones are positive or not for the territory and the population. The ambits involved by this indicator are two: the transport infrastructures and the transport demand. The last ambit is concerned because the transport demand is and important driving force as causes changes on the supply (transport infrastructures) that can deeply modify the land use asset.
The compliance of this indicator with the criteria is good; in particular, it is suitable to depict the long term effects of plans and programmes because the change of the land use and of its value are not immediate and become evident on the long term. Concerning the easiness of calculation and updating, the mark is little bit lower than the previous indicators only because it has to pass through the intermediate step concerning the knowledge of the land use value; anyway this parameter is easy to be obtained by the real estate market.

10. Proximity (m) of transport infrastructures to the ecologically, cultural, social, and landscape rich areas

The development of the transport network, and its continue extension to not yet compromised areas risks aggravating further the conflicts between infrastructure development and nature, culture, society and landscape conservation.
As depicted by EEA in the TERM project, expanding transport infrastructure networks poses a serious threat to designated nature areas. As regards wetlands, 72 % of those of the ACs and 63 % of those of the EU have at least one type of infrastructure within 5 km from their centres. The same applies to 66 % of EU areas designated under the EU birds directive. Further expansion of the transport infrastructure and intensification of its use could jeopardise the future of many important designated nature areas. It is also increasingly difficult to designate new areas for protection that are not affected by infrastructure networks.
On this basis TERM proposed the indicator "Proximity of transport infrastructure to designated areas" to preserve biodiversity and protect designated nature areas[5].
Here we want to go further this indicator, enlarging the meaning given to proximity and considering the indication given by the EU Directive (2001/42/EC), Annex I, comma f. Thus, we consider here the areas important under the ecological, cultural, social, and landscape side. The implementation of the directive on the assessment of the effects of certain plans and programmes on the environment could in future help to avoid conflicts between transport infrastructure planning and the conservation of the aforementioned areas, allowing not only for the preservation of biodiversity and insurance of connectivity between designated nature areas, but also the preservation of the landscape and the conservation of cultural and social traditions.
In this basis we propose a quite simple method of calculation of this indicator based on the measure of the shortest distance between the transport infrastructure and the considered

[5]http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/consequences/TERM07%2C2002/TERM_2002_07_EUAC_Proximity_to_designated_areas.pdf

area, weighted in function of the length of the perimeter facing the infrastructure in respect to the whole perimeter of the area, as depicted in figure 4.
The ambits concerned by this indicator are the transport infrastructures and the environment, considered in its large meaning (thus, not only the natural, but also the cultural components of the environment: forests, rivers, fields, animals, human beings, residential and industrial areas, roads, railways, and their history).

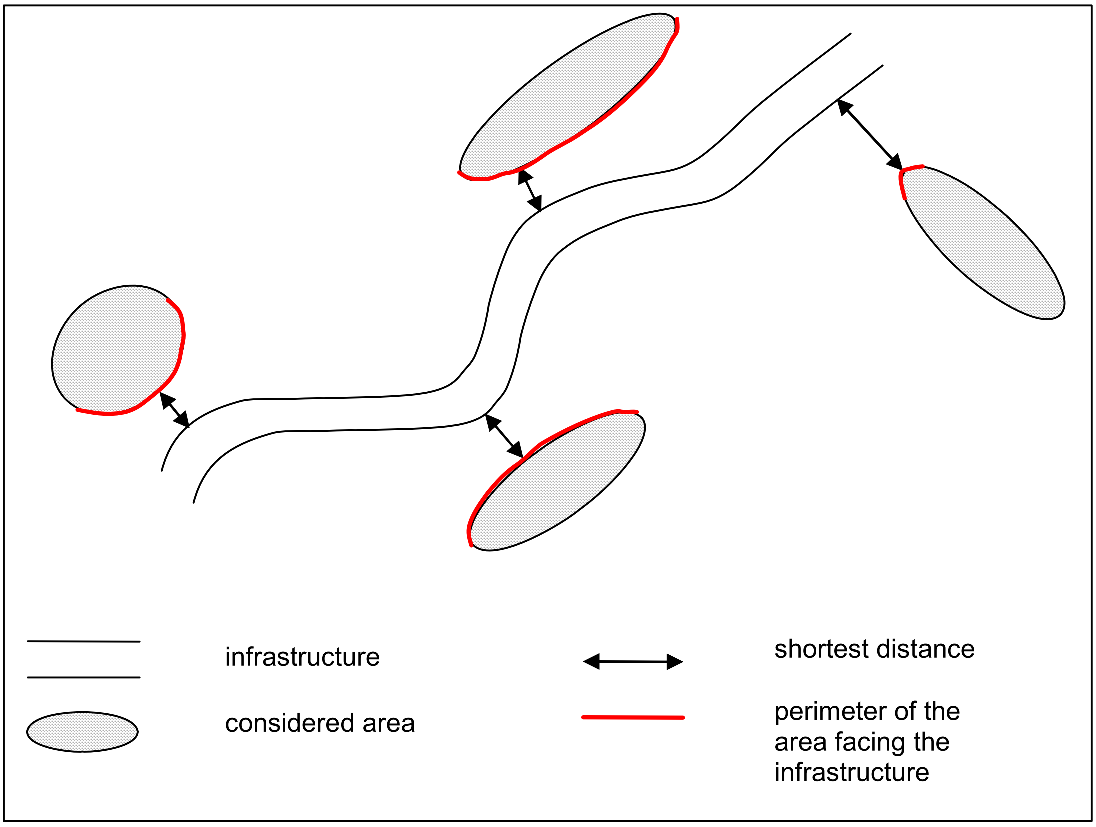

Figure 4 – Representation of the concept of "proximity" indicator

11. Percentage of people living in the areas along the infrastructures (250 m per each side) in respect to the population living in the plan area

This indicator expresses the *human footprint* caused by the transport infrastructures on population affected by them. It is a proxy variable for the exposed people to air pollution and noise, but also to visual impact. It explains how many people are potentially affected by the pollution/uneasiness caused by the infrastructures. We consider this indicator a proxy because it that can be easily used without pass through the calculation of the air pollutant, noise and visual impact that are quite difficult to be defined as explained hereafter.
Lets remember that to give an indication of air pollution we should to calculate at least the emissions, and, to know more and compare it with the law limits also the concentration. If we want to calculate the emissions we should use the following formula:

*g/km (emission factor) * km (road length)*

where the emission factor is calculated with an emission model (e.g. COPERT) and the transport data for the emission model are:
- average speed on the links of the network
- vehicle typology classified in terms of registration year; cylinder capacity, fuel.

The road length is calculated by the road data base or hypothesized if the road is provided and not existing yet.

If we want to continue and calculate the air pollutants concentration we should to use the dispersion models that are complex and need a lot of input data to run.

Concerning noise, to obtain the noise levels (and noise maps) expressed as Leq during the day, evening and night, we should to use suitable software that need data (morphologic and transport data), time and human resources to give valuable results. In alternative we could to use empirical models, less complex, but the main transport data as traffic volumes and typology are always needed. Then, the noise values should be weighted in respect to the exposed people to understand how many people are exposed to certain noise levels.
For the visual impact the calculation could be less complex and more qualitative (e.g. vertical surface occupied by the infrastructures) and, anyway, it should be weighted in function of the people visual field.
To consider directly the rate of people living in a "pertinence area" of 250 meters per side of the infrastructure in respect to the total people living in the area of intervention of plans and programmes is much more simple that to pass through the use of models requesting a lot of data. The data concerning people are available from the territorial plans and are well known and easily obtainable.
The compliance with the criteria is very good and the ambits involved by this indicator are the transport infrastructures and the environment.

12. Rate of area dedicated to interventions focused to reduce the transport demand (e.g. pricing policies, zone 30, etc.)/plan area surface:

This last indicator gives indications about the "direction" of the plan in term of favouring the management of transport demand and the mode diversion to less pollutant modes.
The plans and programmes considered as sustainable should to pay attention to intervene on the territory causing less negative effects as possible. A simple way to foresee the degree of importance of the effects of plans and programmes is to consider how many interventions are dedicated to the transport management and, hence, are focused to control and reduce the transport demand (not increasing the trips). The way to do this is to use different tools as economical instrument as the pricing and/or "structural" actions as avoiding or reducing the vehicle circulation in certain zones, etc.
The way of calculation is absolutely simple because it depends on the design of the plan as provided by the decision makers supported by the technicians; thus the data comes from the existing situation or from forecasted situation and not any kind of calculation is requested.
The compliance with the proposed criteria is very good and the ambit concerned is the transport demand.

Lets consider now the second step of our approach, as depicted in table 4 that can be read as follows:

- the first number (from 1 to 3) indicates the ambit concerned, depicted in the second column;
- the second column contains the three ambits considered:
  - environment;
  - transport infrastructures;
  - transport demand;
- the third column contains the indicator;
- the fourth column gives the unit of measure of the indicator;
- the fifth column indicates the way to calculate the indicator and is divided in two sub-columns: the formula and the method and data to be put in the formula;
- the last columns give the numeration of the indicators. Some numbers are repeated when the same indicator can be used in more ambits.

This demonstrates that the three ambits (environment, transport infrastructures and transport demand) are strongly interconnected, so that the same indicators can appear in cells in different ambits. This emphasizes that we could use the indicators relatives to the ambit of infrastructures and transport demand to well describe the effects on the environment. In this way we could avoid to use complex environmental models, using not enough detailed data, to provide estimates of the transport impacts on the environment. As there is a direct cause-effect relationship between transport and environmental impacts, a good knowledge on the transport data and a choice of the most appropriate data for the strategic level (coming from monitoring or from models) can be the key to provide the trends indicating if a plan is sustainable or not.

1.3.5 Conclusive remarks

The analysis of the proposed transport indicators and the observation of their compliance with the selected criteria allow for some conclusive remarks giving some suggestions to the decision makers for their use in the transport plans, programmes and policies (plans and programmes). The evidence leads to propose as good proxy for the environmental indicators, and hence usable in the SEA, the transport indicators from 3 to 12 because they comply perfectly with the selected criteria. The indicators number 1 and 2 have not god performances in terms of calculation, updating, use of simple raw data, and reliability. This means that they are less easily usable in a SEA where the decisions are often taken without having a good and complete knowledge on data important for the calculation of the effects of plans and programmes on the environment.

As a last consideration, lets remember that the Territorial Information System represents a very useful tool in the use of indicators. This system facilitates the representation of indicators in an immediate and easy way and, in addition, it can helps to cross the different information and to build “aggregate indicators”.

In the next chapter, the approach followed here will proceed from a macro to a more micro approach going into a major detail and focusing mainly on the environmental indicators.

Table 3 – The transport indicators for the SEA: motivation of the choice and satisfaction of the selection criteria

Indicator		Motivation	Ambit	Criteria									
				Relevance to the objectives of the plan	Ability to evaluate the long term effects (impacts) of the plan	Ability to monitor the effects of the plan, giving the trends and allowing the comparability across the time	Transferability in time (different time periods)	Transferability in space (different geographical areas)	Utility at different geographical levels (local, regional, national)	Easiness of calculation	Easiness of updating	Use of raw data needed to calculate the indicator which are available or obtainable in an easy and not expensive way	Reliability of the calculation methods used to define the indicator
1	Accessibility	To guarantee the accessibility is one of the general objectives of every the transport plans, at every geographical level	Transport infrastructures Transport demand	3	3	3	3	3	3	1	1	1	1
2	Level of Service (LOS)	It gives clear indications on the traffic volumes, speed, congestion and comfort, and, consequently, is a proxy for the evaluation of pollutant emissions and noise	Transport infrastructures Transport Demand	3	3	3	3	3	3	1	1	1	1
3	Rate (%) cycle path surface./roads surface	It gives indications about the “direction” of the plan in term of favouring the less pollutant transport modes	Transport infrastructures	3	3	3	3	3	3	3	3	3	3
4	Rate (%) reserved roadway surface/plan area surface	It gives indications about the rate of area reserved for transport in respect to the area available for all the other human activities	Transport infrastructures	3	3	3	3	3	3	3	3	3	3
5	Rate (%) surface for public transport / reserved roadway surface	It gives indications about the “direction” of the plan in term of favouring the less pollutant transport modes	Transport infrastructures	3	3	3	3	3	3	3	3	3	3
6	Network extension (km) of public transport lines	It gives indications about the “direction” of the plan in term of favouring the less pollutant transport modes	Transport infrastructures	3	3	3	3	3	3	3	3	3	3
7	Rate (%) number of interchange parking places/parking places	It gives indications about the “direction” of the plan in term of favouring intermodality	Transport infrastructures	3	3	3	3	3	3	3	3	3	3

continues

Table 3 (continues) – The transport indicators for the SEA: motivation of the choice and satisfaction of the selection criteria

Indicator		Motivation	Ambit	Criteria									
				Relevance to the objectives of the plan	Ability to evaluate the long term effects (impacts) of the plan	Ability to monitor the effects of the plan, giving the trends and allowing the comparability across the	Transferability in time (different time periods)	Transferability in space (different geographical areas)	Utility at different geographical levels (local, regional, national)	Easiness of calculation	Easiness of updating	Use of raw data needed to calculate the indicator which are available or obtainable in an easy and not	Reliability of the calculation methods used to define the indicator
8	Roads Length (km) inside ecologically rich areas (Natura 2000, National Parks, etc.)	It enables to establish a correlation with the barrier-effect inside this areas (and it allows an approach to how much of the area is being fragmentised in addition to other projects or occupancy)	Transport infrastructure s Environment	3	3	3	3	3	3	3	3	3	3
9	Changes of the land use value	It quantifies the loss of important and/or pre-established land uses. Each kind of land use has a value. The area occupied by the road is quantified and, then, weighted by the value of the land use	Transport infrastructure s Transport demand	2	2	2	2	2	2	2	2	2	2
1 0	Proximity (m) of transport infrastructures to the ecologically, cultural, social, and landscape rich areas	It allows for the conservation of biodiversity and insurance of connectivity between designated nature areas	Transport infrastructure s Environment	3	3	3	3	3	3	3	3	3	3
1 1	Percentage of people living in the areas along the infrastructures (250 m per each side) in respect to the population living in the plan area	It is a proxy variable for the exposed people to air pollution and noise. It explains how many people are potentially affected by the pollution caused by the infrastructures without calculate the pollutant emissions and the noise (not simple calculation). It gives also the indication on the people affected by the visual impact of the infrastructures	Transport infrastructure s Environment	3	3	3	3	3	3	3	3	3	3
1 2	Rate of area dedicated to interventions focused to reduce the transport demand (e.g. pricing policies, zone 30, etc.)/plan area surface	It gives indications about the “direction” of the plan in term of favouring the management of transport demand and the mode diversion to less pollutant modes	Transport demand	3	3	3	3	3	2	3	3	3	3

Table 4 – The transport indicators for the SEA

ID	Ambit	Indicator	Unit of measure	Method used for the calculation		ID
				Formula or parameter	Model/measurement/survey	
1	TRANSPORT INFRASTRUCTURES	Accessibility	km or hours	Average journey length for purpose and mode	See the indicators from EEA (European Environmental Agency) concerning the theme of "transport" (TERM) http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/spatial/TERM14%2C2001/index_html)	1
		Level of Service (LOS)	Qualitative index (A to F)	An infrastructure segment can be characterized by three performance measures: density in terms of passenger cars per kilometre per lane, speed in terms of mean passenger-car speed, and volume-to-capacity (v/c) ratio. Each of these measures is an indication of how well traffic flow is being accommodated by the infrastructure. The measure used to provide an estimate of level of service is density. The three measures of speed, density, and flow or volume are interrelated. If values for two of these measures are known, the third can be computed.	The Highways Capacity Manual (HCM 2000) provide the method and table to calculate the LOS	2
		Rate (%) cycle path surface/roads surface	%	m^2 cycling lane surface/ m^2 road surface	The cycling lanes and road surface is calculated by the road data base and territorial/urban plan or hypothesized if the cycle path/road are provided and not existing yet	3
		Rate (%) reserved roadway surface/plan area surface	%	m^2 road surface/ m^2 total area surface	The road surface is calculated by the road data base or hypothesized if the road is provided and not existing yet. The plan area surface is derived by the territorial plans	4

continues

Table 4 (continues) – The transport indicators for the SEA

ID	Ambit	Indicator	Unit of measure	Method used for the calculation		ID
				Formula or parameter	Model/measurement/survey	
1	TRANSPORT INFRASTRUCTURES	Rate (%) surface for public transport / reserved roadway surface	%	m^2 public transport lines surface/ m^2 road surface	The public transport and road surface are calculated by the road data base, public transport companies' data base and the territorial plans or hypothesized if the infrastructures are provided and not existing yet	5
		Network extension (km) of public transport lines	km	Length of the public transport lines	The length of the public transport lines are calculated by the public transport companies' data base and the territorial plans or hypothesized if the infrastructures are provided and not existing yet	6
		Rate (%) number of interchange parking places/parking places	%	Number of places in the interchange parking/ total number of parking places	The number of places in parking are derived by the public transport companies' data base and the territorial plans or hypothesized if the infrastructures are provided and not existing yet	7
		Roads Length inside ecologically rich areas (Natura 2000, National Parks)	km	Road length	The road length is calculated by the road data base or hypothesized if the road is provided and not existing yet	8
		Changes of the land use value	Euros	Value (€/m^2) of the area before the infrastructures * the area surface (m^2) – (minus) the weighted value (€/m^2) of the areas composing the new scenario after the construction of the infrastructures * the sum of the areas' surface (m^2)	The data are taken fro the territorial plans. The value of the areas are given for the market of the real estate	9
		Proximity of transport infrastructures to the ecologically, cultural, social, and landscape rich areas	m	(shortest distance area-infrastructure) * (perimeter of the area facing the infrastructure/whole perimeter)	The proximity is calculated by the territorial plans or hypothesized if the road is provided and not existing yet	10
		Percentage of people living in the areas along the infrastructures (250 m per each side) in respect to the population living in the plan area	%	People in the pertinence area/total people of the area	The people living in the pertinence areas are gathered by the territorial plans	11

Table 4 (continues) – The transport indicators for the SEA

ID	Ambit	Indicator	Unit of measure	Method used for the calculation		ID
				Formula or parameter	Model/measurement/survey	
2	TRANSPORT DEMAND	Accessibility	km	See indicator n° 1	See indicator n° 1	1
		Level of service (LOS)	Qualitative index (A to F)	See indicator n° 2	See indicator n° 2	2
		Changes of the land use value	Euros	See indicator n° 9	See indicator n° 9	9
		Rate of area dedicated to interventions focused to reduce the transport demand (e.g. pricing policies, zone 30, etc.)/plan area surface	%	Area surface dedicated to interventions/ total area	The data are taken fro the territorial plans and from hypotheses where the policies are not in action yet	12
3	ENVIRONMENT	Roads Length inside ecologically rich areas (Natura 2000, National Parks, etc.)	km	Road length	The road length is calculated by the road data base or hypothesized if the road is provided and not existing yet	8
		Proximity of transport infrastructures to the ecologically, cultural, social, and landscape rich areas	m	distance	The proximity is calculated by the territorial plans or hypothesized if the road is provided and not existing yet	10
		Percentage of people living in the areas along the infrastructures (250 m per each side) in respect to the population living in the plan area	%	People in the pertinence area/total people of the area	The people living in the pertinence areas are gathered by the territorial plans	11