



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

Part C
Chapter 6
Monitoring of environmental impacts
in the context of SEA of traffic and
transport infrastructure: Experience
of COST350

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Introduction

This chapter wants to provide a basis to make the monitoring of SEA of transport Plans and programmes and it is focused on and four main concepts:

- the indicators and data used for the monitoring;
- the two different alternatives to practice monitoring: well defined targets or non defined targets;
- the time interval to adopt;
- the informative system to manage the monitoring.

1. Indicators and data of monitoring

The implementation of transport Plans and programmes provides the preparation of a SEA and the relative monitoring plan. This constitutes a framework for further (lower tier) planning and decision-making, and also for the project level because the impacts produced by the projects can be worsened or improved by the Plans and programmes' provisions. For this reason, the SEA is developed during the planning process as also the monitoring plan which should be included in the SEA report. Decision-makers should adopt the monitoring plan as a condition of Plans and programmes approval, to reduce the uncertainties at the time of approval.

Following the concept of *ex ante* and *in itinere* SEA, mentioned above, the monitoring should concern all the indicators defined in the chapters 3 and 4, concerning the transport and environmental indicators. This implies the monitoring of the data needed for the calculation of these indicators. Moreover, we make an overview of the time interval of monitoring, according the time scale of the plan on the one hand, but also the time scale of the different impacts we would like to monitor trough the different indicators we have selected.

A good reference for the Plans and programmes environmental assessment is the sequence DSPIR (determinant – pressure – state – impacts – response) to which add two elements [Angeli, 2005]:

- the *performance of the response*, given by the ratio between environmental effectiveness and response costs, where the environmental effectiveness is given by the environmental impact of the response and is valuated through the indicator of impact (e.g. reduction of the noise level to which a certain population is subjected), and the cost is represented by the monetary social cost of the response;
- the *target of the response*: the objective of the response effectiveness, expressed in quantitative terms and fixed at a determined time deadline.

To evaluate the environmental effectiveness of transport Plans and programmes, the actions provided by Plans and programmes have to be firstly defined and identified in terms of DPSIR that means:

- to identify the determinant forces and the subsequent environmental pressures put in force by the Plans and programmes (or not dependent on the Plans and programmes, but considered because the Plans and programmes have to control and maintain them within the sustainability);

- to define the quality of the state of the environmental components subjected to the pressures and the types of impacts the pressures have on the components;
- to point the responses (constraints, incentives, mitigations, reclamations, compensations) the plan can implement to guarantee the environmental sustainability of the determinant forces and relative pressures.

This implies two steps:

- the quantification and spatial transformation of each element of the DPSIR sequence;
- the modelling of the cause-effect relationship linking each element to another, defining the reaction times of the system (mainly the time necessary to see the effects of the responses).

The first step, the quantification of the elements of the sequence, occur thanks to appropriate indicators. The evaluation of the environmental effectiveness of the Plans and programmes responses implies the estimate of the change of the impact indicator on which the state quality of the environmental components depends: it is impossible to evaluate the Plans and programmes performances without the use of indicators.

Then, the spatial effect of the phenomena playing a role – determinant forces, the pressures, the sensible environmental components and the impacts – has to be taken into account. Each determinant, as each response, has an own location having a punctual, linear or surface shape. Around the location there is usually a spread of the environmental pressure, more or less extended in function of the pressure intensity and of the potential of diffusion of the context. The location of the determinant and the ambit of spreading of the pressure form “the spatial footprint of the impact”: each impact indicator has an own spatial footprint, concept not separable from the definition itself of indicator.

The degree of sensitivity of a certain environmental component (e.g. population, ecosystems, landscape, etc.) is variable in the space: stronger is the sensitivity of the environmental component in the area of the impact spatial footprint and higher is the pressure level, stronger will be the impact on the component.

The cartographical representation of the impact spatial footprint and of the component sensitivity is a main step for the environmental evaluation and, hence, of the monitoring. Thus, the success of the monitoring depends on the possibility to associate indicators simple to monitor to the Plans and programmes’ actions. The indicator can be depicted as a function $y = f(x)$, where x are the independent variables to monitor for the calculation of the impact y variation. The term x represents also the factors on which the actions of the Plans and programmes have to act to cause a reduction of the impact. If the Plans and programmes actions able to modify the x do not exist, the impact of type y is out of the control of the Plans and programmes. The effectiveness of the Plans and programmes’ actions will be given by a Δy depending on the action capability to modify the x . For this reason the x have to have a sufficient degree of sensitivity to record the changes produced by the actions: they have to be defined at the right space scale and their unit of variation has to be lower than the smallest variation caused by the action.

As just mentioned, it is not said that all the x can be influenced by the Plans and programmes’ actions and then the Plans and programmes assume them as exogenous and not influenceable variables, also if these are valuable in terms of their environmental effects, thanks to the impact indicator. In the same way, there can be some x dependent on several competing factors (as also the Plans and programmes actions): in this case the monitoring system has to be calibrated to

distinguish the contribution of the Plans and programmes action from the contribution of other competing factors.

1.1. Indicators

The definition of a system of indicators, easy to monitor and focused to the evaluation of the cumulative environmental impacts, has to put in relation the transport infrastructures with the land use changes. In that respect, three sets of indicators are defined: one set of indicators for each abstraction level of information availability (Part C, chapter 4). These indicators make possible the assessment of the environmental impacts of traffic and transport infrastructures, according to the quality and quantity of information available at the transport action (alternative) level [Goger, 2005].

Few environmental effects can be nevertheless unforeseen. In that particular context, the monitoring applied to the set of indicators selected does not bring any information on the trend or the compliance of the objectives by the plan. For unforeseen environmental effects, the monitoring may also be referred to monitoring activities not depending on a special plan or programme.

To monitor different types of unforeseen negative environmental effects of the implementation of single plans or programmes effectively, different methodological approaches can be used. Which approaches are suitable in the individual case depends on the planning level and the connected contents of the respective plan or programme (table 1).

Monitoring approaches	upper planning level (e.g. national)	lower planning level (e.g. corridor)
Implementation control	(X)	X
Specific new elevation of environmental data	(X)	X
Usage of existing monitoring activities	X	(X)
Indicator system	X	(X)
Environmental assessment at the following lower planning level	X	--
Environmental assessment at the plan extrapolation	X	(X)

X = well suitably, = (X) restrictedly suitably

Table 1: Methodological approaches of monitoring at different planning levels

Furthermore, the effectiveness of avoidance, reduction or compensation measures, can have a significant impact on the environmental effects actually appearing. Since, it may make technically sense to monitor not only the real environmental effects (through the monitoring of the set of indicators selected), but also possible causes of unforeseen environmental consequences. The monitoring of the implementation of the plan or programme should also be a component of the monitoring concept. When necessary, additional easily monitored indicators may be added [European Commission, 2001]. These added indicators should be meaningful and appropriate for

the level of decision-making involved (national or local) and the abstraction level of information available of the transport alternative. Such indicators are also very linked to the transport alternative considered. In consequence, identification of these eventual indicators is a special task and cannot be included in a general approach of monitoring.

Here, only a new approach of monitoring of known environmental impacts of traffic and transport infrastructures in the context of SEA of transport alternatives is developed. The approach is build as a flexible method, based on using one of the three sets of indicators elaborated according three abstraction levels of information availability (table 2).

Level Low (1)	Level Intermediate (2)	Level High (3)
Accessibility	Land uptake	Land uptake
Level of Service (LOS)	Fragmentation of habitats	Fragmentation of habitats
Rate (%) cycle path surface./roads surface	Visual disturbances	Visual disturbances
Rate (%) reserved roadway surface/plan area surface	Consumption of non-renewable raw materials and recycling of waste in construction	Consumption of non-renewable raw materials and recycling of waste in construction
Rate (%) surface for public transport / reserved roadway surface	Concentration of pollutants in soils	Concentration of pollutants in soils
Network extension (km) of public transport lines	Concentration of pollutants in surface water	Concentration of pollutants in surface water
Rate (%) number of interchange parking places/parking places	Use of fossil fuels /renewable energy	Use of fossil fuels /renewable energy
Roads Length (km) inside ecologically rich areas (Natura 2000, National Parks, etc.)	Disturbance from noise	Disturbance from noise
Changes of the land use value	Sensitive Pollution	Sensitive Pollution
Proximity (m) of transport infrastructures to the ecologically, cultural, social, and landscape rich areas	Climate Change	Climate Change
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	Acidification	Acidification
Rate of area dedicated to interventions focused to reduce the transport demand (e.g. pricing policies, zone 30, etc.)/plan area surface	Photochemical pollution	Photochemical pollution
	Toxicity	Toxicity
	Ecotoxicity	Ecotoxicity
	Eutrophication	Eutrophication
	Release of dangerous goods due to accidents	Release of dangerous goods due to accidents
	Accidents	Accidents
	Hydraulic risks	Hydraulic risks

Table 2: Monitoring of indicators for the three different abstraction level of information

When the information availability relative to a transport alternative corresponds to the abstraction level 1 (the lowest level of data availability) or the need of decision makers is to understand in a simple and direct way the effects of the Plans and programmes actions, we suggest to monitor the Plans and programmes environmental impacts using indicators of low level (where few information is available).

Monitoring can be done with indicators of low level at every abstraction levels of information, because “transport oriented indicators” (like transport volume) are indirect indicators in respect to the environment, and can be used as a proxy to estimate environmental effects (like noise and pollution) (chapter 3) [Arts & coll., 2002; Eea, 1998; European Commission, 1999; 2001; Fauconnier, 1995; Friend & coll., 1997].

Nevertheless, if necessary, indicators of intermediate (in-between level) or high (where a lot of information is available) level, may be useful if the decision makers need a more detailed and precise monitoring. As a matter of fact, indicators of intermediate and high levels are more precise and exhaustive, and are often linked with clear and significant environmental objectives, which is not obviously the case for indicators of low level. Moreover, most of the indicators of intermediate and high levels can be arithmetically deduced from indicators of low level; this does not imply any difficulty in the calculation of these indicators at these abstraction levels of information.

The choice of the relevant indicators’ set results, firstly, from the abstraction level of the available information, and, secondly, from the choice of experts and decision-makers responsible for the Plans and programmes SEA. Thus, when the situation corresponds to the high level, there is the possibility to choose a set of indicators corresponding to low, intermediate or high level. If the situation corresponds to the intermediate level, there is possibility to choose a set of indicators corresponding only to low or high level. Finally, when the situation corresponds to the low level, the set of indicators corresponding to low level is the only one available.

1.2. Data

Every indicators developed following the proposed methodology are calculated thanks to data coming out from models or measurements. The monitoring of the indicators implies, as consequence, the monitoring of the data used to obtain the aforementioned indicators. In table 3 a synthesis of the elements need to the monitoring of indicators is given.

Level	Indicator	Data
1	Accessibility	Average journey length for purpose and mode (km or hours)
1	Level of Service (LOS)	An infrastructure segment can be characterized by three performance measures: density in terms of passenger cars per kilometer 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.
1	Rate (%) cycle path surface./roads surface	m^2 cycling lane surface/ m^2 road surface
1	Rate (%) reserved roadway surface/plan area surface	m^2 road surface/ m^2 total area surface
1	Rate (%) surface for public transport / reserved roadway surface	m^2 public transport lines surface/ m^2 road surface
1	Network extension (km) of public transport lines	Length of the public transport lines (km)
1	Rate (%) number of interchange	Number of places in the interchange parking/ total number of parking

	parking places/parking places	places
1	Roads Length (km) inside ecologically rich areas (Natura 2000, National Parks, etc.)	Road length (km)
1	Changes of the land use value	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)
1	Proximity (m) of transport infrastructures to the ecologically, cultural, social, and landscape rich areas	(shortest distance area-infrastructure) * (perimeter of the area facing the infrastructure/whole perimeter)
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	People in the pertinence area/total people of the area
1	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
2	Land uptake	Natural habitat area lost (m ²) Domestic and recreation area lost (m ²) Sealed area (m ²)
2	Fragmentation of habitats	Fragmentation of landscape (total area). Fragmentation and barrier effects to population. Fragmentation and barrier effects to habitats.
2	Visual disturbances	Valuable areas available (e.g. regional planning) or creatable (GIS-interpretation of land-use) Effect's magnitude
2	Consumption of non-renewable raw materials and recycling of waste in construction	construction material (t) % of recycled materials in it
2	Concentration of pollutants in soils	the mix of vehicle types (in particular passenger cars and trucks) the maximum vehicle velocity the presence of protection facilities elevation of road relative to its surroundings
2	Concentration of pollutants in surface water	concentration of each pollutant in the water run-off parameters of the natural recipient the natural recipient's water quality
2	Use of fossil fuels /renewable energy	specific fuel consumption (l/100 km, kg/100 km) of the vehicles (vehicle categories) operation circumstances (average speed, distances)
2	Disturbance from noise	the density of population, the distance to settlements (for national, regional and local levels) or the distance to the first (sometimes also the second) line of buildings (for corridor level),

		the building structures organization The percentage of people living in the areas along the infrastructures
2	Sensitive Pollution	
2	Climate Change	CO ₂ emissions (kt/year)
2	Acidification	NO _x and SO ₂ emissions (t/year)
2	Photochemical pollution	CO, NMVOC, NO _x emissions (t/year)
2	Toxicity	Cu, HAP, PM ₁₀ , PM _{2.5} , PM ₁ , NO ₂ and SO ₂ emissions (kg)
2	Ecotoxicity	Cu, HAP, PM ₁₀ , PM _{2.5} , PM ₁ , NO ₂ and SO ₂ emissions (kg/year)
2	Eutrophication	NO _x emissions (t/year)
2	Release of dangerous goods due to accidents	routes of dangerous goods transport. On this basis there is need to assess the sensitivity of the environment in every route surrounding
2	Accidents	number of accident or number of victims (killed/injured) <i>or accident severity</i>
2	Hydraulic risks	type of land usage at the threatened territory, number of people living at this territory and using the groundwater for their daily life (as potable water), number of protected species living at the threatened territory.
3	Land uptake	Same as indicator of level 2
3	Fragmentation of habitats	(i) Km of road or equivalent causing the “annoyance” geometrical definition of interested areas.,(ii) types of habitats, their size and importance, (iii) the number and type of ecoducts.
	Visual disturbances	Same as indicator of level 2
	Consumption of non-renewable raw materials and recycling of waste in construction	Same as indicator of level 2
	Concentration of pollutants in soils	Same as indicator of level 2
	Concentration of pollutants in surface water	Same as indicator of level 2
	Use of fossil fuels /renewable energy	Same as indicator of level 2
	Disturbance from noise	Same as indicator of level 2
	Sensitive Pollution	
	Climate Change	Same as indicator of level 2
	Acidification	Same as indicator of level 2
	Photochemical pollution	Same as indicator of level 2
	Toxicity	Same as indicator of level 2
	Ecotoxicity	Same as indicator of level 2
	Eutrophication	Same as indicator of level 2
	Release of dangerous goods due to accidents	Same as indicator of level 2
3	Accidents	Same as indicator of level 2

3	Hydraulic risks	Same as indicator of level 2
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Table 3 : The indicators and the data needed to calculate them

2. Targets

Even if well-defined targets are a prerequisite for monitoring and should therefore exist in every cases, they often don't exist in the transport planning practice. Often the targets are not so concrete as they should be. For this reason there should be a possibility to monitor in a proper way, even if the targets aren't as concrete as required.

Therefore you can distinguish between two situations:

- well-defined targets are available; (The results of the indicators can be compared directly with the targets)
- well-defined targets are not available (An analysis of the trend of the indicators is necessary).

2.1. Well-defined Targets

The monitoring of the environmental impacts is often carried out comparing the result of indicators with a target [Arts & coll., 2002; Arya & coll., 2001; Inyang & coll., 2003; Pepper & coll., 1996; Wmo, 1999]. Clearly defined targets are thus required.

In order to be functional, targets have to satisfy the following theoretical conditions:

- a measurability/possibility to be controlled (ordinal or cardinal measurability),
- a spatial specification,
- a temporal specification,
- designation of responsibilities,
- definition of sub-aims/indicators.

In the context of the Plans and programmes SEA, transport and environmental targets should be defined by bodies such as transport ministries. These should sub-divide the targets to the networks and corridors under their responsibility [European Commission, 2001]. If this is not done as part of a transport-environmental policy, such targets have to be derived from environmental policy in the framework of SEAs [European Commission, 1999].

In respect to the general approach for the monitoring we suggest that only transport-environmental targets derived from environmental policy are concerned, because the other ones should be defined by the responsible authorities, and are specific to the SEA of the Plans and programmes they are responsible for. Indicators and recommended general targets are presented in table 4.

Level	Indicator	Objective
1	Accessibility	To guarantee the accessibility is one of the general objectives of every the transport plans, at every geographical level
1	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
1	Rate (%) cycle path surface./roads surface	It gives indications about the “direction” of the plan in term of favouring the less pollutant transport modes
1	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
1	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
1	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
1	Rate (%) number of interchange parking places/parking places	It gives indications about the “direction” of the plan in term of favouring intermodality
1	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 fragmented in addition to other projects or occupancy)
1	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
1	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
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
1	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
2	Land uptake	In Germany for example a land take target of 30 ha per day by 2020 (compared to the actual 100-120 ha per day has been proposed)
2	Fragmentation of habitats	<p>Preserve a high rate of Biodiversity in Europe. Safeguard the capacity to sustain a large number of species inside protected areas (SPA, RAMSAR). Minimise annoyance close to designated areas and most of all diminish as far as possible the “Fragmentation Island effect-edge effect” [2]</p> <p>Fulfil the “prospective” of Birds (CEC, 1979) and Habitats (CEC, 1992) Directives that aim at protecting more than 10 % of the territory of the EU.</p> <p>Pan-European Biological and Landscape Diversity Strategy (1995 – signed by 54 countries)</p> <p>Policy actions to achieve the EU's target of halting the loss of biodiversity by 2010.[4]</p>
2	Visual disturbances	
2	Consumption of non-renewable raw materials and recycling of waste in construction	Some 50-60% of the overall solid waste stream is land filled, though the proportion of land filled waste varies substantially in individual Member States and ranges from under 30% in Holland and Luxembourg to

		virtually 100% in Ireland, Portugal and Greece.
2	Concentration of pollutants in soils	Soil Framework Directive (in coming)
2	Concentration of pollutants in surface water	Water Framework Directive (2000/60/EC)
2	Use of fossil fuels /renewable energy	According to the Directive 2003/30/EC on the promotion of renewable fuels for transport a minimum proportion of biofuels 5,75% shall be achieved by 31.12.2010. The target of the Green Book of EC is 20 % of fuels placed on the market for transport purposes by 2020.
2	Disturbance from noise	Directive 2002/49/EC of 25 June 2002
2	Sensitive Pollution	
2	Climate Change	Kyoto protocol
2	Acidification	NEC directive 2001/81/CE
2	Photochemical pollution	NEC directive 2001/81/CE
2	Toxicity	Aarhus protocol NEC directive 2001/81/CE
2	Ecotoxicity	Aarhus protocol NEC directive 2001/81/CE
2	Eutrophication	NEC directive 2001/81/CE
2	Release of dangerous goods due to accidents	
2	Accidents	The goal of the EU-Commission (4) is to halve the number of deaths until 2010 (on the basis of 2000: 40.000 deaths in EU-15, 50.000 in EU-25).
2	Hydraulic risks	Water Framework Directive (2000/60/EC)
3	Land uptake	Same as objective of level 2
3	Fragmentation of habitats	Same as objective of level 2
	Visual disturbances	Same as objective of level 2
	Consumption of non-renewable raw materials and recycling of waste in construction	Same as objective of level 2
	Concentration of pollutants in soils	Same as objective of level 2
	Concentration of pollutants in surface water	Same as objective of level 2
	Use of fossil fuels /renewable energy	Same as objective of level 2
	Disturbance from noise	Same as objective of level 2
	Sensitive Pollution	Same as objective of level 2
	Climate Change	Same as objective of level 2
	Acidification	Same as objective of level 2
	Photochemical pollution	Same as objective of level 2
	Toxicity	Same as objective of level 2
	Ecotoxicity	Same as objective of level 2
	Eutrophication	Same as objective of level 2

	Release of dangerous goods due to accidents	Same as objective of level 2
3	Accidents	Same as objective of level 2
3	Hydraulic risks	Same as objective of level 2

Table 4: Indicators and targets

2.2. Non well-defined targets

A certain "lack of well-defined targets" can be observed in the transport-environment field. This lack may result from the difficulty to identify elaborated targets, and to express them as the value assumed by the indicators. Moreover, Plans and programmes are often embedded in a contradictory context of different targets.

The fact that a plan or programme cannot be regarded as totally completed is also another difficulty to monitor environmental impacts through the use of well-defined targets [European Commission, 1999; 2001]. In this respect, looking at the trend of indicators and defining fuzzy targets should be an appropriate alternative to the strict comparison between indicators and well-defined targets.

The trend gives a general idea if the plan goes in the right or in the wrong direction, and if it goes slowly or quickly [Arts & coll., 2002; Arya & coll., 2001; Evers & coll., 2005; Inyang & coll., 2003]. This approach is obviously less precise than the previous approach, but it can be considered as a proxy to monitor environmental impacts of an alternative, considering that direction and velocity of trends are the most important point of the monitoring.

The decision-makers get also both well-defined targets and trends as different approaches available. We suggest following the trend of indicators to monitor environmental impacts first of all. If authority needs a more precise monitoring and if information is available, it may be recommended to monitor environmental impacts of the transport alternative concerned, using the comparison between indicators and well-defined targets, as presented previously (§ 2.1).

3. Time interval of monitoring

Temporal specification refers to time interval of monitoring that gives a relationship between indicators result and targets or trends [Arts & coll., 2002; Arya & coll., 2001; European Commission, 1999; 2001; Pepper & coll., 1996]. For instance, monitoring of the climate change indicator may be easily movable to the future without a temporal horizon. Generally, the longer the time interval is, the more the result of monitoring may disappear from the political agenda [European Commission, 1997]. The choice of time interval is, hence, a crucial issue and a very difficult task of the monitoring.

In the context of Plans and programmes SEA, the time interval is balanced between two different points of view.

From the environmental point of view, the monitoring should be linked to the time scale of the environmental impacts assessed, in order that the monitoring brings a relevant information of the result of the plan [Arts & coll., 2002; Inyang & coll., 2003; Pepper & coll., 1996]. The time scale of the different environmental impacts, referenced in chapter 4 and reminded in the table of indicators, is nevertheless very different. For instance, the time scale of green-house effect is a long-term scale, whereas the sensible pollution or noise have a short-term scale (chapter 4). In

that context, it is very difficult to choose a single time interval for every indicator. It may be more relevant to adapt the time interval of the monitoring to each indicator, in respect to the time scale of the impact assessed by each indicator.

From the point of view of the decision maker involved in the Plans and programmes, the time interval of the monitoring should also be sensitive to the effects of the Plans and programmes on the environment. There are two different effects which should be taken into account when the time interval of the monitoring is defined: the direct effects which are directly induced by the Plans and programmes, and the indirect effects involved by social or economical pressures resulting themselves from the Plans and programmes.

After the construction of the transport infrastructure, many direct impacts become irreversible, unless the infrastructure is removed. For instance the impacts which are caused by the physical presence of the infrastructure as land uptake cannot be removed. After construction, however, pressures on the environment that are caused by traffic can still be influenced to some extent. In consequence, direct effects of the plan designed to influence traffic flows (e.g. ecotaxes, vehicle taxes, traffic diversion to public transport) should have an influence on the choice of time interval of the monitoring.

New transport infrastructures influence, in addition, the long-term development of settlement patterns of people and the economic activities. These factors influence the traffic flows, and therefore should be accounted for in transport-environment monitoring. They are indirect effects of the transport Plans and programmes on the environment, because the Plans and programmes affect firstly social and economic development, and then this development involves a modification of the traffic which induces environmental impacts. Thus, the time scale of the indirect environmental impacts may be very significant for the choice of the time interval of the monitoring, in the context of the Plans and programmes SEA.

In respect to the aforementioned considerations, the choice of only one time interval for the monitoring of all the impacts cannot be appropriate. In consequence, it may be recommended to monitor the Plans and programmes' environmental impacts according the time interval suggested by the EC: three years after the beginning of the plan for the short-term effects, fifteen years for the medium-term effects, and fifty years for the long-term effects [European Commission, 1997; 1999; 2001].

4. Structure of information system for the monitoring

The set up of an information system to carry out the monitoring, we have to consider several problems, constraints and opportunities [Angeli, 2005]:

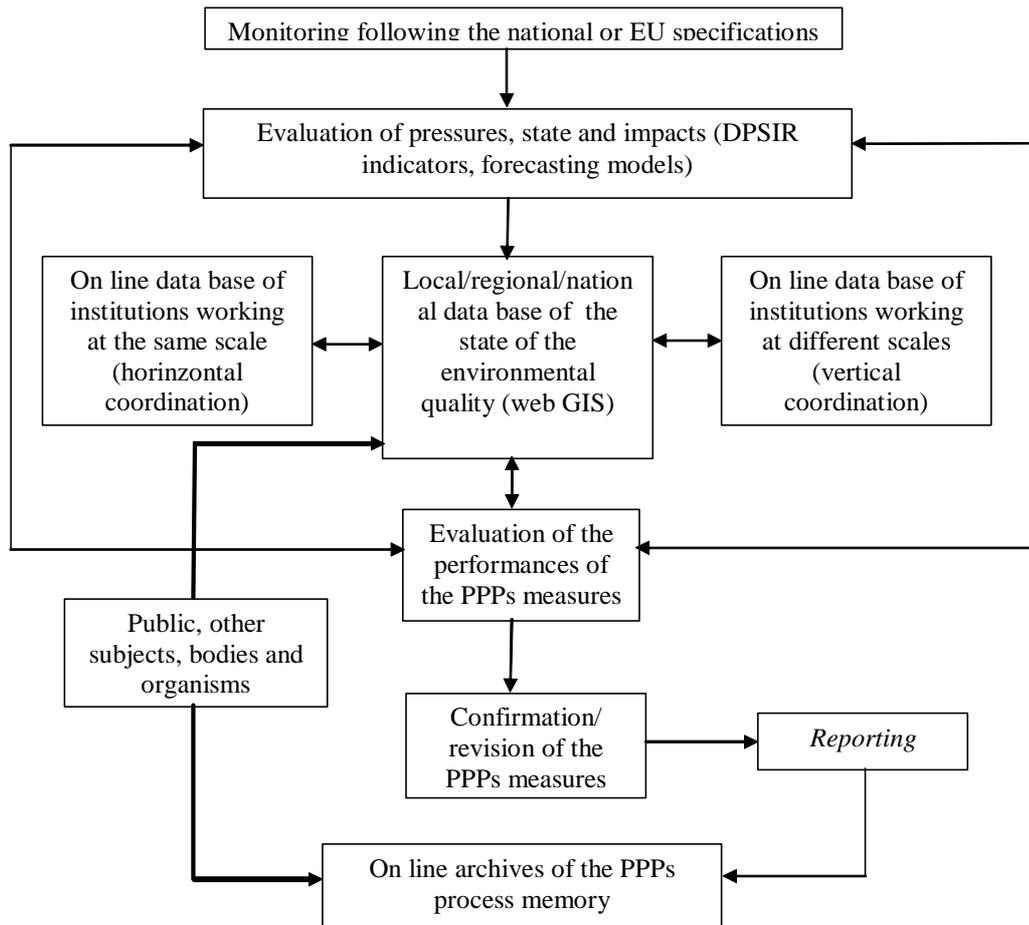
- there is a huge amount of information and data representing the mechanism of the system, of its quality, of the measures put in force by the Plans and programmes, and of their effectiveness and continuous update;
- the time flow of the information and data has to be updated in function of the chosen time interval (§ 3) and is fed by the monitoring that should be based on a geo-referred data base;
- the geo-referred data base is the input for the analyses and elaborations to evaluate, through the indicators, the state of quality of the system and the effectiveness of the measures provided by the PPP;
- the aforementioned evaluation feeds the decision making process for the revision and updating of the Plans and programmes;

- the data base is not only a tool for the planner, but it has to give informative flows both in vertical (among institutions at different hierarchical levels) and in horizontal (among institutions at the same level). This implies that the information have to can be aggregated in a vertical way and have to be comparable at the horizontal level with the information coming from other transport Plans and programmes data bases. Thus, the data base has to be accessible to the different institutions, local, regional and national;
- following the principle of the transparency of the public information, as those contained in the transport Plans and programmes, the accessibility to the data base should be extended also to the citizens and to the territory in general; this is a basic principle of the e-government and could lead to the e-planning thanks to making available the informative flows of data, in real time, to make public the information of the plan process.

In figure 1, the functional flow chart of the information system is depicted where the thin lines show the informative flows internal to the local/regional/national information system, while the bold lines show the potential connections through the web.

The system in figure 1 is characterized by different functions:

- *monitoring*. This is linked to a data base prepared following precise national specifications (or better some standardized characteristics at EU level) and integrated with the updating of the data base containing the information on the pressures and on the Plans and programmes interventions;
- *data elaboration and on line data base updating*. The data of the monitoring system come together in a data base where, through the evaluation methods based on the DPSIR indicators and on mathematical models allowing the simulation of the system (PPP) behaviour, they interpret and elaborate the data following the aforementioned national or EU specifications. The data base at local/regional/national level is accessible, through the web, to the data bases of other institutions cooperating on the transport planning process, guaranteeing the needed horizontal and vertical flows of data.;
- *evaluation, revision and reporting*. These functions should be carried out by the decision support system and they are main functions for the Plans and programmes management, where the performances of the adopted measures are evaluated and, if necessary, the changes are made and documented through the reporting. Each change of the values of the indicators and of the Plans and programmes measures updates the data base. The time series of the reports is archived and is possible to consult it on line. This is the historical memory of the Plans and programmes, very useful to orient the future actions provided by Plans and programmes on the basis of the past experience.



Source: Elaboration for Regione Piemonte (2005 [Angeli, 2005]).

Figure 1: Flow chart of the information system and of the monitoring following an e-planning scheme

The advantages of such an on line informative systems are clear:

- the information are constantly updated;
- the system is accessible to each interested subject;
- as the system is integrated in a data base network, it allows for the informative cooperation, strengthening the knowledge;
- as the system is conservative in terms of the past experiences, it enhances the ability to foresee and plan the future;
- thanks to the increase of the knowledge, the system becomes the main “map” for the transport system and the relative environmental effects;

- the system improves the transparency of the decisional process and facilitates the other bodies or public participation.

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