A decision-making tool for a sustainable modal and spatial split of transalpine freight traffic

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Abstract
Freight traffic through the Alps is growing significantly. The better adaptability of road transport to the requirements of production and distribution systems explains why the growth concerns essentially this mode of transport. The expansion of road transport results in increased air pollution, noise, congestion, and safety concerns. The advent of the concept of sustainable development has called current modal split of freight traffic into questions. To complete the approach of the sustainable development problem which principally focuses on the temporal dimension, looking for equity between generations, this research proposes a territorial approach, looking for the spatial dimension and the equity inside generations.

In this context, this research project develops a methodology for a tool, which will help decision-makers to assess the vulnerability of crossed areas considering freight traffic volumes (on railway and/or road) and the sensitivity of the receivers present on the crossed areas or components of these areas. This generic tool will provide a global view of freight traffic impacts on crossed areas like alpine valleys. The development of indicators will be helpful to reach a more sustainable freight traffic system, especially for decisions concerning modal and spatial transfers of transalpine freight traffic.

1. The transalpine freight traffic and its impacts on the crossed areas

1.1 The growth of freight traffic
The significant growth of freight traffic over the two last decades is observed on national, European and world scale. Synergy among different factors tends to increase and internationalise freight traffic. These factors are, for example, the globalisation of economic activity, the increase of trade, the evolution of the production process

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2 For ECMT (European Conference of Ministers of Transport) countries. In: PROFILLIDIS / BOILE, / 2001
with the specialisation of production units and the development of «just-in-time» delivery, the improvement of infrastructure, the technological innovations and also the lower price of transport.

The better adaptability of road transport to the requirements of production and distribution system explains why the growth of freight traffic concerns essentially this mode of transport. Nowadays the development of road transport is worrying because it induces a growth of freight traffic, congestion problems which have major socio-economical consequences, environmental impacts and also public health impacts. These impacts induced by freight traffic through air pollution, noise, congestion and lack of safety are very different according to the mode of transport and to scale.

The evolution is particularly worrying in the Alpine region, where the traffic is concentrated on a limited number of routes. Beside that, the topography causes a limited dispersion of atmospheric pollutants (valleys) and higher energy consumptions are needed due to the gradients of transport infrastructures. This induces a higher production of pollutants, linked to the vehicle traction (acclivity).

1.2 Towards a more sustainable modal and spatial split

The growth of freight traffic and the increase of the sensitivity to the environment, the human health and the well-being represent two contemporary and contradictory aspirations. The advent of the concept of sustainable development incited European countries to find a solution for stabilizing or decreasing the impacts of freight traffic. A consensus about the necessity of balancing the use of the different modes of transport and particularly to increase the use of railway has been found. The objective of intermodality results in the most efficient use of the existing transport infrastructures as result of the optimisation of freight traffic distribution on the different transport modes.

Thus, the research presented in this document focuses on impacts induced by freight traffic volumes without considering the impacts linked to the existence of

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3 In 2010, cost of congestion in Europe is estimated at about 80 billions Euros. In: European Communities / 2001

4 This concentration is linked to the limited exchanges between the different air masses (channelling of the winds in valleys, frequent thermal reversals) and to the profile of the slopes.

5 The expression « sustainable development » has been proposed for the first time in the «World Conservation Strategy» published by the IUCN (The World Conservation Union), 1980

6 « Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. » in Brundtland Commission / 1987
transport infrastructure. However, the questioning about the modal split of freight traffic raises also the question of its spatial distribution. To contribute to the research of a more sustainable transport system, this research aims to develop a tool for splitting freight traffic on different modes of transport and/or routes according to the vulnerability of the crossed areas.

2. A new approach to assess the vulnerability of the crossed areas

2.1 The spatial dimension of sustainable development

The focus on the modal\(^7\) and spatial split of freight traffic and the relation between freight traffic nuisances\(^8\) and their impacts on the crossed areas explains the interest in the spatial (territorial) dimension of the sustainable development concept (figure 1 / p.5).

Despite a lot of different approaches, the sustainable development problem principally focuses on the temporal dimension. This is also the case in the transport sector, where most of the studies look for a compromise between traffic growth and environmental protection\(^9\). The emphasis is put on the notion of equity between generations. It is interesting to complete this approach with the consideration of the equity inside one generation to take the spatial dimension into account: « the spell concern or, at least, the consideration of the interests of future generations have a sense only if it takes the present generation into account with its variable situations. In this respect, levels of well-being according to the territories represent a main variable.»\(^10\). However, it remains difficult to define what is called sustainable and this sustainability will probably never be reached on the whole territory.

2.2 To model the vulnerability

To model the impacts of freight traffic on crossed areas, the assumption is made that the relation between freight traffic and the territory can be more or less conflicting

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\(^7\) Railway and road (more than 3,5 tones vehicles).

\(^8\) The choice has been made for a non economic approach, negatives externalities will be gathered under the term nuisances. An externality is an « economic cost, which is not normally taken into account in the market or in decision of the market agents. ». « Some of these externalities represent increase of attacks on the natural environment: noise and atmospheric pollution. Some others have a different form: growth of accident risks and increase of congestion. » in OECD-ECMT / 1998

\(^9\) FEITELSON / 2002

\(^10\) LAGANIER / VILLALBA / ZUINDEAU / 2002
according to the volume of traffic and the sensitivity of the receivers\textsuperscript{11} present on the crossed areas or components of these areas. This relation depends on the transported volumes, on the utilised transport mode and on the environmental, social and economic characteristics of the crossed area.

To put traffic and territory in relation, the notion of vulnerability is used. This notion represents a link between the disruptive element, the traffic, and the vulnerable element, the territory (figure 1 / p.5). The notion of sensitivity, contrary to the notion of vulnerability, exists regardless to the nuisances subjected to the considered area. The notion of vulnerability takes the importance and the frequency of disruptions (hazard) and the environmental, social and economic values of the elements which could be affected into account.

\textsuperscript{11} Receivers are for example: the population, the fauna, the vegetation, the soil, the water.
A model to assess the vulnerability of crossed areas

Figure 13

Concept of Sustainable Development (environment, society, economy)

- Temporal dimension
- Territorial/spatial dimension
  - Equity between generations
  - Equity inside each generation

Growth of Freight Traffic

Disruptive element

Vulnerability (impact level)

Importance of the disruption

Sensitivity (risk to transmit the disruption)

Environmental, social and economic value of the vulnerable elements (receivers)

Sensitivity to the environment, the human health and the well-being

Two contemporary and contradictory aspirations supply research in a sustainable transport system

Equity inside each generation

Space

Length
3. The development of vulnerability’s indicators using a GIS\textsuperscript{12} and multicriteria analysis

3.1 GIS and multicriteria analysis

This research combines two tools to assess the vulnerability of crossed areas according to the volumes of traffic and to the receivers.

A GIS is used to collect, standardise, manage (consistency and maintenance) and create data. The GIS is interesting to model the spatial repartition of data and is also efficient for spatial analysis because it contains a set of proceedings for data describing the territory.

The multicriteria analysis is needed to synthesise all the available information, i.e. all the data coming from the GIS. In this research, this method is interesting to standardise and to weight different criteria of vulnerability and, on this basis, to develop indicators.

3.2 From criteria to indicators of vulnerability

First of all, criteria of vulnerability are defined. They model the interaction between the receivers and the nuisances (figure 2 / p. 7).

From the weighting of these criteria, indicators will be obtained. Indicators $R$ represent the vulnerability of receivers considering several nuisances and indicators $N$ represent the vulnerability of several receivers considering only one nuisance.

Principally according to the topography and to the level of urbanisation, crossed areas will be defined and delimited. Thus, it will be possible to compare similar crossed areas like Alpine valleys, flat high urbanized areas and flat less urbanised areas.

All these crossed areas will be partitioned into polygons. The size and the form of the polygons depend on the chosen resolution (grid), which depends on the scale and on data availability. For each polygon it will be possible to obtain indicators $R$ and / or indicators $N$.

Considering all the indicators $R$ and / or $N$ of all the polygons included in a crossed area, global indicators $R$ and / or $N$ will be calculated for each of the crossed areas. For similar crossed areas it will then be possible to compare global indicators and to identify which areas are the more vulnerable according to the volumes of freight traffic on the different modes of transport.

\textsuperscript{12} Geographic Information System
4. A decision-making tool

4.1 A methodology for the alpine segment

The objective of this research is to develop a decision-making tool for the Alpine region located between the Mont Cenis / Fréjus tunnels and the Brenner Pass. This part of the Alps represents the Alpine segment\textsuperscript{13}. The French Alpine crossings (Mont Cenis / Fréjus, Mt Blanc), the Swiss Alpine crossings (Grand St Bernhard, Simplon, Gotthard, San Bernardino) and the Brenner Pass in Austria are the most attractive crossings for north/south freight traffic through the Alps (figure 3 / p. 8).

However, the method will be tested on a national level (Switzerland), where there is more precise and homogenous data. The test segment contains the following Swiss Alpine crossings: Grand St Bernhard, Simplon, Gotthard, San Bernardino. The methodology will also be tested with only one receiver: the population. The vulnerability of this receiver to several nuisances like air pollution, noise, congestion or safety concerns will be assessed.

Buffers delimit the research area around the transport infrastructures. The buffers’ size depends on the nuisances (some kilometres). The time period is one year (data average). If possible, diurnal (5 am - 10 pm) and nocturnal (10 pm – 5 am) periods will be distinguished.

\textsuperscript{13} ARE / 2001
4.1.1 Towards a more sustainable modal and spatial split of freight traffic

The main purpose of this tool is to help decision-makers to take decisions meeting the objectives of sustainable development.

This tool will be able to provide a global view of the impacts induced by freight traffic according to the traffic volumes on railway and/or on road and to the environmental, social and economic characteristics of the crossed areas.

For this research, the assumption is made that whatever the extent of the disruption is, the disruption has an impact on receivers. There is no question of using thresholds under which the value is considered as nil.

Indicators will be helpful to reach a more sustainable freight traffic system and especially for decisions concerning modal and spatial transfers of freight traffic.

The application of this tool concerns the Alps but it will be possible to use this generic tool for other traffic and other areas (on the local, regional or national level).

In conclusion, this decision-making tool will be able to:
- explain the vulnerability (sources, nuisances, receivers);
- identify the more vulnerable areas;
- compare similar crossed areas and different routes;
- observe spatial inequalities;
- provide and test assumptions relating to modal or spatial transfers of freight traffic volumes.
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