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## GREEN PAPER

on

The Impact of Transport on the Environment

A Community strategy for "*sustainable mobility*"

(Communication from the Commission)

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A Community strategy for "sustainable mobility"

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## I. GENERAL INTRODUCTION

### a. Preliminary comments

1. The impact of transport on the environment is coming under close scrutiny in the industrialised world and more particularly in the Community. The global nature of environmental issues - such as the "greenhouse effect" - has led to a growing awareness of the need for a world-wide approach to environmental problems.

This global approach in turn has highlighted the need to focus on the causes of environmental problems in a different manner. It is no longer considered sufficient to assess the primary or immediate causes, but to go to the very root of the problem - human behaviour. Thus, the Bergen Declaration<sup>(1)</sup> stresses that "unsustainable patterns of production and consumption, particularly in industrialised countries, are at the root of numerous environmental problems, notably foreclosing options for future generations by depletion of the resource base".<sup>(1)</sup> It warns that "the attainment of sustainable development... requires fundamental changes in human values towards the environment and in patterns of behaviour and consumption..."<sup>(1)</sup> and in this respect highlights the need "to reduce the harmful effects of the transport sector on the environment by promoting fast, safe, and convenient urban and regional transport services and reducing urban car traffic" <sup>(1)</sup>. Also noted, is the need to encourage low transport demand.

2. Hence, a number of human activities, of which transport, has come under close scrutiny. Indeed, transport is increasingly being qualified as a human activity with a negative impact on the environment. A clear illustration of this is the concern about the environmental nuisance and damage caused by the high level of traffic in sensitive geographical areas such as

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(1) Bergen Ministerial Declaration on sustainable Development in the ECE Region, 16 May 1990, p. 2, 4 and 11.

the Alps, as well as in densely populated areas, particularly large conurbations.

This view is also endorsed by the Group Transport 2000 Plus in its report "Transport in a Fast Changing Europe", which identifies transport as a major contributor to energy and environmental problems since it is one of the main consumers of fossil fuels and is responsible for considerable nuisance and damage to the environment<sup>(1)</sup>.

**b. Historical background**

3. Following the declarations at the Paris Summit in October 1972 a decisive political impetus was given to consideration of the environment in planning the socio-economic development of the Community. As a result, the Commission adopted a first Action Programme on the Environment for the period 1973 to 1977. The main concern was to ensure the proper functioning of the Common Market by amongst others introducing harmonised standards for consumer products.

Hence, for the transport sector this programme provided for technical improvements of noise and gaseous emissions of motor vehicles as well as for the maximum content of lead in fuel. It also provided for specific action in the area of marine pollution resulting from sea transport. The programme already drew attention to transport problems in the urban environment.

4. The second Action Programme for the period 1977 to 1981 continued the same line of action. It concentrated as far as transport was concerned on marine pollution, measures to reduce noise from motor vehicles, motor cycles and aircraft.

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(1) Group Transport 2000 Plus, Transport in a Fast Changing Europe, December, 1990.

The third Action Programme for the period 1982-1986, however, introduced a new dimension into the general philosophy. Environmental policy was to be motivated by the fact that the environment itself contains the limits to further economic and social development. This Action Programme stressed the need for a greater awareness of the environmental dimension in the area of transport. Vehicle emissions, aircraft noise and the environmental impact assessment of infrastructure projects were earmarked as priorities.

5. It is only in the fourth Action Programme for 1987-1992 that the interaction between transport and the environment is duly recognised as being of a wide-ranging nature.

This new approach was the result of the Single Act which in Article 130 R provides that environmental protection requirements shall be a component of the Community's other policies. This approach was endorsed in the Declaration by the European Council of June 1990, which stresses the need for sustainable and environmentally sound development as advocated in the 1987 Report "Our Common Future" by the World Commission on Environment and Development (the Brundtland Report).

6. A more specific response in this direction was given by the Commission in April 1989, when it was deemed necessary to reflect on the relationship between environmental policy and other Community policies, in particular in the field of transport. The outcome of this exercise provided the guidelines for further work in this area with a view to examine the impact of transport on the environment in a global and coherent framework.
7. This Green Paper is the logical follow-up to that initial response as well as to the world-wide concern about a number of global environmental issues. The Community position on 'global warming' as reflected in the Conclusions of the Joint Energy and Environment Council of 29 October 1990 on Climate Change Policy and its commitment to the stabilisation of CO<sub>2</sub>

emissions by the year 2000 and the possibility of reductions thereafter confirms this concern as well as the need for action.

This Green Paper is also in line with the guidelines on urban transport policy set out in the Commission Green Paper on the Urban environment<sup>(1)</sup> and takes account of the need to create new opportunities for the peripheral regions so that they may share fully in the prosperity of the Single Market as set out in the Commission Communication 'Europe 2000'.<sup>(2)</sup>

It is also a response to the Resolution adopted by the European Parliament in September 1991, which calls upon "the Commission to submit to the Council a framework programme for optimum environmental protection in the European transport market."<sup>(3)</sup>

8. This Paper is also in line with the forthcoming Fifth Action Programme on the Environment "Towards Sustainability", which outlines a new policy and strategy for the protection of the environment and natural resources and the achievement of sustainable development.

The approach adopted differs fundamentally from that of previous Environmental Action Programmes, since it focuses on the agents and activities which deplete natural resources and damage the environment. Its objective is to initiate changes in current trends and practices which are detrimental to the environment, so as to ensure socio-economic well-being and growth for present and future generations. Such changes are to be achieved through shared responsibility, involving public administrations, public as well as private enterprise and the general public, in accordance with the principle of subsidiarity.

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(1) [COM(90)218 final of 27 June 1990]

(2) [COM (91) 452 final of 7 November 1991]

(3) PE 145.075/end of September 1991

The Fifth Action Programme focuses on five main economic "target" sectors, including the transport sector, and includes actions designed for the protection of the environment as well as for the benefit and sustainable development of the sectors themselves.

This Paper converts and adapts the objectives and targets included in the Fifth Action Programme into a global and coherent strategy for the transport sector.

9. This Green Paper provides an assessment of the overall impact of transport on the environment and presents a Common strategy for "*sustainable mobility*" which should enable transport to fulfil its economic and social role while containing its harmful effects on the environment.

The purpose of the Paper is to initiate a public debate on how to achieve the objectives of such a strategy which is to be subsequently fully integrated into the forthcoming White Paper on the future development of transport policy in the Community.

The principle of subsidiarity will play an important part in ensuring that the strategy is given its full effect by appropriate national, regional and local initiatives.

Clearly, many of the areas discussed in this Paper are areas in which the Community's contribution will not be legislative - but may be in the research field, in standard setting, or in the definition of objectives. The legislative role may in such cases fall to Member States, or to local or regional authorities. The purpose of this Paper is to initiate discussion, rather than to programme a series of Community legislative acts.

## 11. PROBLEMS AND ISSUES

### a. Current issues

10. The 1989 and 1990 Scientific Assessments of the Intergovernmental Panel on Climate Change (IPCC) has drawn world-wide attention to the causes and consequences of the "greenhouse effect". Although scientific evidence is not yet conclusive as to the scale of the problem, there is general agreement that the high atmospheric concentrations of "greenhouse gases" will have an effect on the earth's climate, causing the "warming" of the globe and the ensuing rise in the average sea levels.

Energy-generation, industry and transport have been identified as the major sources of carbon dioxide, which is the main man-made "greenhouse gas".

11. The depletion of the ozone layer, which reduces the protection of the earth against ultra-violet radiation from the sun, is caused by emissions of chlorofluorocarbons (CFCs) and halons. The direct contribution of transport to this phenomenon is due mainly to the refrigerated transport of goods and air-conditioned vehicles.

No less important but more restricted in its geographical range is the phenomenon of "acid rain", which affects animal and plant life and corrodes building materials. Transport contributes to "acid rain" through sulphur and nitrogen oxide emissions.

12. Other current issues include the build-up of ozone in the troposphere, caused by the emission of volatile organic compounds and nitrogen oxides, with harmful effects on human health and animal life. Transport contributes to this phenomenon.

13. All these current issues concern different forms of atmospheric pollution.

Another current issue is that of the damage to which the urban environment is exposed. Transport is considered to be one of the root causes of present urban degradation.

**b. The role of transport**

14. For the purpose of this Green Paper transport includes the carriage of goods and persons by any mode of transport - road, rail, inland waterways, sea and air -, private or public, for payment or not, irrespective of the purpose - private or commercial. Traffic represents the physical result of transport.

Transport is vital to both our economic and social well being. It is vital to the production and distribution of goods and services as well as to trade and regional development.

15. Since the beginning of the 1950's transport has made a major contribution to economic growth and has enabled the achievement of economies of scale in production and, by increasing competition in hitherto protected markets, has led to a wider range of choice for both the producer and the consumer with direct and indirect effects on the quality of life.

Transport has also contributed to the significant growth of tourism, which accounts for over 5 % of GDP and provides over 8 million jobs.

16. In the Community the transport sector contributes approximately 7% to the Gross Domestic Product and represents 7% of employment<sup>(1)</sup>. These figures go up to 10% and 9% respectively, if transport for own account of both goods and persons as well as the production of transport means and infrastructure are included<sup>(2)</sup>.

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(1) Group Transport 2000 Plus, op.cit, p. 5.

(2) E. Jacobs, Le marché européen unique : un défi pour la politique des transports, 1990, p. 4-5.

According to OECD estimates the socio-economic cost - including pollution, congestion and accidents - in the case of road transport could, however, be as high as 5% of GDP<sup>(1)</sup>. This estimate does not represent the full external cost of transport since it does not cover all forms of environmental impact - namely the cost of the "greenhouse effect" - and is limited to only one transport sector.

17. Technological developments since the beginning of the 1950's have enabled people to travel more quickly, more often and over longer distances, breaking down economic, social, national, ethnic and geographical barriers.

These developments have led to the mass movement of people and have greatly affected behaviour patterns and the general way of life, particularly in industrialised countries. The advent of the motor car and its widespread availability have encouraged a way of life where people feel entitled to mobility and the absence of a private means of transport is often felt as a handicap since it reduces access to available amenities.

#### c. Impact of transport on the environment

18. For the purpose of this paper environment includes the quality of life, living conditions of human beings and the natural environment with suitable habitats for animals and plants. The quality of life is determined by the long-term availability in sufficient quantity and of adequate quality of resources such as water, air, land and space in general as well as raw materials. It also includes the natural and cultural heritage.
19. Apart from initiatives in the shipping sector to prevent damage to the marine environment, the impact of transport on the environment was, until recently, viewed mainly in terms of atmospheric pollution and noise emissions.

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(1) OECD (1988) : Transports et Environnement, Paris, 1988, p. 11.

Efforts to control atmospheric pollution caused by transport concentrated only on emissions of certain pollutants emitted by motor vehicles. Emission standards were introduced in industrialised countries for carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO<sub>x</sub>) and diesel particulates. The Community adopted legislation to reduce vehicle emissions as well as to encourage the use of unleaded petrol. Community standards have been regularly adapted to technological progress.

20. In the case of noise emissions, industrialised countries introduced limits for cars, buses, goods vehicles, motor-cycles and aircraft. The Community adopted limits on noise emissions for goods and passenger vehicles, as well as for motorcycles, and introduced legislation for the phasing out of the noisiest aircraft. No limits were introduced for noise emissions from railways.

21. This approach was one-sided, since these measures were limited largely to vehicle emissions and, thus, were confined to only one aspect of the impact of a single transport sector on the environment.

However, all power-driven transport affects the environment and generates pollution. The impact is not limited to atmospheric pollution and varies in scale and range according to the mode of transport.

22. Thus, in order to ensure the widest possible assessment of the impact of transport on the environment the analysis in this Green Paper is based on a number of criteria related to the quality of the environment as defined above. These criteria include the operational impact of transport on air, water and soil as well as the quality of life, the impact of transport infrastructure on space, the consequences of congestion as

well as the risks inherent to the transport of dangerous goods. The analysis also provides an assessment of the specific problems caused by transport and traffic in the urban environment.

### III. ENVIRONMENTAL IMPACT

23. Since transport has a wide-ranging impact on the environment, the present analysis is based as stated above on a number of criteria related to the quality of the environment. These include operational pollution, land-use, congestion and the risks inherent to the transport of dangerous goods.

#### a. Operational pollution

24. Operational pollution is caused by the actual use of the different means of transport. It affects the air, water and soil and produces noise and vibrations. The effects in many instances are long-term and cumulative, although those caused by noise and vibrations are of an immediate and transient nature.

#### "Air"

25. "Air pollution" is caused by the emission of chemical substances into the atmosphere which alter its composition, with harmful effects for human health, animal and plant life. The effects of some pollutants remain within the vicinity of the source, where concentrations are highest, and thus have mainly a local impact as in the case of lead emissions. The effects of other pollutants are suffered well beyond the vicinity of the source, as in the case of SO<sub>2</sub> emissions, which contribute to "acid rain". Pollutants can, however, also have a "global" impact as in the case of CO<sub>2</sub> and other greenhouse gases, which affect the climate of the whole planet.

26. Emissions from transport sources include the following air pollutants:

- . carbon dioxide (CO<sub>2</sub>) emitted by the combustion of fossil fuel
- . carbon monoxide (CO), hydrocarbons (HC) and volatile organic compounds (VOC), resulting from incomplete combustion
- . nitrogen oxides (NO<sub>x</sub>) generated at high combustion temperatures
- . lead (Pb), ethylene dibromide and dichloride added to gasoline to attain the desired octane rating and greater volatility of combustion by-products
- . sulphur dioxide (SO<sub>2</sub>) due to the higher sulphur content of diesel
- . fine particles present in diesel
- . formaldehyde and other aldehydes

Carbon dioxide, methane and nitrous oxide contribute directly to the "greenhouse effect" whereas nitrogen oxides, carbon monoxide and hydrocarbons contribute indirectly.

Sulphur dioxide and nitrogen oxides contribute to the phenomenon of "acid rain".

VOCs and nitrogen oxides contribute to the build-up of ozone concentrations in the troposphere.

Hydrocarbons, VOCs, lead, aldehydes, ethylene dibromide and dichloride have potential carcinogenic effects, whereas lead, carbon monoxide and diesel particles are generally detrimental to human health.

27. Air pollution caused by the transport sector is almost exclusively related to the consumption of - mostly non-renewable - energy. According to Eurostat figures for 1988 energy consumption in the transport sector reached 211.53 MTOE (1) (= 29.8% of total final energy consumption).

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(1) Millions of tonnes of oil equivalent.

This is comparable to the energy consumption of industry which represents one third of final energy consumption in the Community.

Within the transport sector 84.4 % was used by road, 11.1% by aviation, 2.5% by railways and 2.0% by inland waterways. Therefore, it is useful to compare energy consumption for different means of transport.

28. Although the results of comparative research in this field should be interpreted with caution, they nevertheless give a clear indication of the energy "greediness" of the different means of transport as shown for passenger transport in table 1 and figure 1.

In fact in the passenger sector they reflect mainly the different basic assumptions concerning i.a. the type of vehicle/train/aircraft taken as reference, the driving circumstances in the case of road vehicles, the average speed, the average energy consumption, the total passenger capacity, the occupancy rate, the production structure of electricity for electric powered trains.

It is clear that the average occupancy rate, which varies largely from one mode to another, is one of the key variables in intermodal comparisons. Therefore, table 2 and figure 2 give a comparison of the specific energy consumption for different transport modes at different occupancy rates, namely 25%, 50%, 75% and 100%.

29. In order to make a fair comparison, the energy intensiveness - also referred to as specific energy consumption - is measured in megajoules of primary energy, taking into account losses occurring during the production and transmission process, per passenger-km.

The main conclusions on the basis of table 2 and figures 1 and 2 are that

- . for the private motor vehicle there is a considerable difference between small and large vehicles;
  - . within each mode the energy effectiveness is commensurate with the occupancy rate;
  - . of all modes the specific energy consumption is the highest for airplanes;
  - . compared to high speed trains energy consumption is twice as high for aviation;
  - . at full capacity railways and buses have the lowest consumption.
30. The latter is particularly important in the case of rush-hour traffic where the occupancy rate of cars is very low (between 1 and 1.2 passenger/car), the driving circumstances and hence the real energy consumption due to congestion very unfavorable and the occupancy rate of trains and buses very high (sometimes exceeding 100% of seating capacity). Although there is no significant difference in energy consumption between railways and buses operating at full capacity, qualitative aspects such as seating comfort, speed, travel time and reliability are usually an advantage for the railways.
31. For freight transport the same considerations regarding intermodal comparisons hold as in the case of passenger transport. Nevertheless the results give an indication of the scale of energy greediness.

Moreover freight transport covers very heterogeneous activities, going from a door-to-door delivery of a refrigerator by van to the customer's home in the city centre,

over long distance transport of steel coils by 40 tonnes 5-axle articulated lorry to intercontinental transport of cut flowers by air. Table 3 and figure 3 give an indication of the energy consumption for different means of inland transport under different circumstances.

32. Railways and inland waterways have the lowest energy consumption at around 0.6 MJ/tonne-km.

For 4 and 5-axle articulated heavy goods vehicles (with a full load on the return journey) the energy consumption would appear to be only slightly higher than for railways and inland waterways (0.7 MJ/tonne-km). However, the present market organization gives rise in practice to considerable empty running and a load factor between 50% and 70% would be a more realistic basis for an intermodal comparison. Under these conditions energy consumption is significantly higher for road haulage. Removal of existing restrictions on market access could greatly contribute to energy efficiency.

In the case of light goods vehicles the specific high energy consumption (between 4 and 8 MJ/tonne-km at full load) is due to the high value/high volume/low weight nature of the goods.

*"The case of CO<sub>2</sub>"*

33. The total amount of CO<sub>2</sub> released into the atmosphere by the transport sector in 1986 reached about 577 Mtons or 22.5% of total CO<sub>2</sub> emissions in the Community (1).

The breakdown of this total output according to the different means of transport reflects the share of each means in the total energy consumption of the transport sector.

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(1) CEC, Energy in Europe, Energy for a new century : the European perspective, special issue, July 1990, p. 228.

Means of transport	Share in total CO <sub>2</sub> emissions by transport sector	
1. Road: total		79.7%
- private car	55.4%	
- goods vehicles	22.7%	
- buses + coaches	1.6%	
2. Aviation		10.9%
3. Railways: total		3.9%
- passengers	2.8%	
- goods	1.1%	
4. Inland waterways		0.7%
5. Other transport		4.3%

Source: Consultant TNO<sup>(1)</sup>

The private car alone accounts for more than 55% of the total CO<sub>2</sub> emissions of the transport sector.

Almost three quarters of the total CO<sub>2</sub> emissions for both road and rail have their origin in passenger transport. (See figure 4).

*"The other pollutants"*

34. Within the context of the CORINAIR programme a detailed analysis on a Community-wide basis is available for NO<sub>x</sub>, VOC and SO<sub>2</sub> emissions by road transport. Only partial data are available for railways and none for inland waterways, shipping and aviation.

The share of road transport in total emissions is 53.6% for NO<sub>x</sub>, 27.1% for VOC and 2.9% for SO<sub>2</sub>. (See table 4)

The share of private cars and light commercial vehicles for the total emissions by road transport is 55.6% for NO<sub>x</sub>, 66.9% for VOC and 49.5% for SO<sub>2</sub>. (See table 4)

(1) TNO Policy Research, Possible Community Measures Aiming at Limiting CO<sub>2</sub> Emissions in the Transportation Sector, Delft, August 1991, p. 6-7.

The share of road transport in total CO emissions is estimated at around 74%. Data for Germany and the Netherlands show that well over 80% is attributable to the private car<sup>(1)</sup>.

35. For particulates and lead, comprehensive data are not available. Data for Germany show that transport is responsible for 13% of total particulate emissions, for the Netherlands the share is as high as 22%, of which  $\pm$  30% is attributable to the private car<sup>(1)</sup>.

As far as lead is concerned data for the Netherlands attribute to road transport a share of 87% of total lead emissions, of which 94% is caused by the private car<sup>(1)</sup>.

36. With regard to the specific problems related to the urban environment, it is worth mentioning that of all pollutants released into the atmosphere by road transport a large part (26% for NO<sub>x</sub>, 61% for VOC) is emitted on urban roads, as data for the Netherlands and Germany show<sup>(1)</sup>. (See table 5).

This is not surprising, since energy consumption and emissions of pollutants differ according to the driving circumstances. As shown in table 6 for the different means of road transport energy consumption and emission are significantly higher in an urban context.

37. No comprehensive Community data are available for the share of the other means of transport in the emissions of the different pollutants. However, figures for the UK show that 97% of non-methane VOC is caused by road transport, 2% by rail and 1% by shipping; 95% of NO<sub>x</sub> is caused by road transport, 3% by rail, 1% by air and 1% by shipping<sup>(2)</sup>. For aviation it is not specified whether the NO<sub>x</sub> emissions include tropospheric pollution, which is an area where research is still in an

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(1) Prognos, Evaluation of External Costs related to Road Transport : Heavy Goods Vehicles (HGV) of Minimum 12 Tonnes Gross Vehicle Weight (GVW), Basel, January 1991, tables.

(2) The Institution of Civil Engineers, Pollution and its Containment, London, 1990, p. 46.

early stage.

Aircraft emissions are becoming a matter of growing concern, particularly those produced in the mid to upper troposphere. It is thought that the impact of "greenhouse gases", particularly NO<sub>x</sub>, is much greater than if produced at ground level.

38. The social costs of atmospheric pollution take into account the cost of health problems: effects on the respiratory system, toxicity due to lead accumulation, the loss of human productivity due to morbidity and mortality and the damage to buildings.

Although results vary, probably because of differences in the methods of estimation, an average cost of 0.3 to 0.4% of GDP seems to emerge. According to a German study 91% of the costs can be attributed to road, 4% to rail, 3% to inland waterways and 2% to air<sup>(1)</sup>.

*"Water"*

39. "Water pollution" is caused by the direct or indirect discharge of chemical substances, including dangerous biological agents and genetically modified organisms and micro-organisms, into the aquatic environment resulting in the alteration of the quality or nature of the water ecosystems with detrimental effects on human health or animal and plant life.

Transport contributes indirectly to ground water pollution through vehicle emissions and aircraft emissions at take-off and landing. Transport accidents involving dangerous or polluting goods can have direct or indirect effects on the water ecosystem.

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(1) Group Transport 2000 Plus, op. cit., figure 16, quoting Fraunhofer Institute Karlsruhe.

Transport contributes directly to surface water pollution through operational discharges from barges and other vessels as well as through accidental discharges of dangerous or polluting goods carried by inland waterways.

40. "Marine pollution" is caused by the discharge - intentional or accidental - of chemical substances, including dangerous biological agents and genetically modified organisms and micro-organisms, into the sea or estuaries with harmful effects for the marine ecosystems resulting in hazards to human health and to animal and plant life.

Sea transport affects the marine environment through operational pollution in the form of intentional and routine discharges caused by operational fall out and loading and unloading of cargo as well as through discharges of dangerous or polluting goods in the case of accidents at sea and in ports. Eighty percent of all oil pollution of the marine environment is caused by operational pollution.

*"Soil"*

41. "Soil pollution" consists of a change in the quality or nature of the soil or its general degradation, caused by chemical or physical interference. Since the soil acts both as a reservoir and filter for water and provides storage of primary mineral water, its contamination by harmful substances or the general degradation of its physical or chemical structure can have far-reaching direct as well as indirect effects on human life as well as plant and animal life.

The close interaction between the ecosystems of soil, air and water increases the vulnerability of the soil and widens the range of the potential effects of soil pollution.

42. Transport contributes indirectly to soil pollution through operational discharges and directly in the case of accidental discharges of dangerous or polluting goods. Transport infrastructure can affect the ecological balance of the soil with repercussions for the ecosystems of water and air.

*"Noise"*

43. "Noise" consists of a number of tonal components which have a harmful effect on human beings and can be more or less intolerable due to the discomfort, fatigue, disturbance and, in some cases, pain it may cause. Depending on its intensity and nature, the effects of noise can range from mere discomfort to various psychological and pathological reactions and vary according to the information imparted by the noise signal and the nervous state and activity of the receiver.

Over the last two decades noise has increased considerably due to the growing spread of urbanization, the greater mobility of goods and persons and the far-reaching mechanization of most human activities.

44. Noise emissions and their impact differ from one transport mode to another.

The overall noise level of road traffic can be broken down into engine noise, rolling noise (from tyres on the road) and other intermittent noise. Under normal traffic conditions the presence of lorries significantly increases average levels of both noise and the number and intensity of noise peaks. Psycho-sociological studies have shown that the noise of a single lorry is equivalent to that of six passenger cars in terms of perceived annoyance. On roads with intermittent traffic the equivalence can be as high as 10 to 15 cars for

one lorry<sup>(1)</sup>. Depending upon traffic conditions for a single lorry the "drive-by" noise, which increases with the speed of the vehicle, is between 6 and 12 d B (A) <sup>(1)</sup><sup>(2)</sup> higher than that of a single car. The annoyance is generally qualified in terms of the population exposed to noise levels exceeding a certain desirable limit value - 55 leq d B (A) <sup>(2)</sup> for new residential areas and 65 leq d B (A) in general.<sup>(3)</sup>

45. In the Community, according to OECD figures, the percentage of population exposed to road transport noise above 55 leq d B (A) varies from 34% (Denmark) to 74% (Spain) and for levels above 65 leq d B (A) from 4,1% (Netherlands) to 23% (Spain). The degree of urbanization, the population density and the structure and density of the road network are important elements which influence the annoyance level.
46. Noise emissions from trains are caused by wheel/rail contact, the engine, aerodynamics, structures along the route and ground vibrations. The noise from wheel/rail interaction increases with speed. In the case of highspeed trains another important source of noise is the contact between the overhead catenary and the train pantograph. Although only a limited number of OECD data are available on railway noise, the percentage of population exposed to railway noise above 55 leq d B (A) is 6% in the Netherlands (no figures available for other Member States) and above 65 leq d B (A) varies from

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(1) DELSEY, J., (INRETS), Nuisances from Heavy Goods Vehicles, ECMT, Paris, January 1991, p. 2.

(2) d B (A): decibel, A-weighted: unit of measurement of sound in which greater emphasis is given to medium and high frequencies to which the human ear is most sensitive. The d B (A) measure is the most usual in noise abatement and control activities.

Leq: "equivalent sound level", gives the average sound level over a given period e.g. a full day or during daytime from 8.00 to 20.00.

(3) ECMT, Transport Policy and the Environment, Paris, 1990, p. 23.

0.3% (United Kingdom) to 1,7% (Germany). The proportion of the population exposed to railway noise depends on the importance of railways in relation to other modes of transport, the density of the railway network and topographical factors.

47. The main source of aircraft noise are the sound emissions from the reactors, which at take-off can exceed 120 d B (A). According to OECD figures, the percentage of population exposed to aircraft noise above 55 leq d b (A) varies from 36% (Netherlands) to 1.7% (Denmark) and above 65 leq d B from 1% (Germany) to 0.3% (Denmark). The annoyance caused by aircraft noise depends mainly on the siting of the airport and on air traffic density.
48. There are no data available for noise emissions from ships and barges since the annoyance factor is virtually negligible.
49. In calculating the social cost of noise for inland transport, loss of productivity, health care, effects on property values and loss of psychological wellbeing are taken into account. Estimates for the total social cost hover around 0.1% of GDP, 64% of which is attributable to road traffic, 26% to aviation and 10% to rail<sup>(1)</sup>.

Overall road has the biggest impact on the quality of life in terms of noise emissions.

*"Vibrations"*

50. "Vibrations" consist of low frequency movements of physical matter. The effects on humans and fauna are broadly similar to those of noise. Vibrations also have harmful effects on soil, buildings and infrastructure, which can range from mere cracks to structural damage.

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(1) Group Transport 2000 Plus, op. cit., figure 16, quoting Fraunhofer Institute Karlsruhe.

51. Road vibrations are caused almost exclusively by heavy goods vehicles driving on roads which are structurally or in lay-out unsuitable for such vehicles. These are mainly roads which are not motorways, giving access to or passing through large and small conurbations. Vibrations are, thus, of particular concern in towns and villages, where streets, buildings and underground services are vulnerable to damage. Vibrations become worse as the state of the road deteriorates.
52. Railway vibrations are determined by local ground conditions, the track bedding system as well as the weight, suspension and speed of the train. Thus, there is a major difference between passenger and freight trains. Passenger trains with their lighter axle loads and sophisticated suspension systems, even at high speed, rarely cause vibrations that are perceptible at a distance of 25 m from the track side. Freight trains, however, with high axle loads and simple suspension systems are the major cause of railway vibrations.
53. Vibrations caused by aircraft on the ground have not led to major concern since this type of nuisance is overpowered by the noise emissions of the engine.
54. There are no standards yet for acceptable levels of vibration for any of the modes of transport, which makes it difficult to assess the scale of the problem.

*Reduction of operational pollution*

55. In order to reduce the different aspects of operational pollution, the "best available technology" should be applied to all transport means including fuel quality and alternatives as well as to infrastructure.

This will require stricter gaseous emission standards for all fuel types, for motor vehicles, (cars, commercial vehicles, buses and coaches), motorcycles, aircraft, ships and barges, stricter noise emission standards for motor vehicles,

motorcycles, trains and aircraft, stricter standards for fuel quality and bio-fuels, stricter energy efficiency requirements for motor engines, aircraft engines, motorcycle engines, ship and barge engines as well as new noise design requirements for roads, railways and runways.

56. The "best available technology" should reduce atmospheric pollution, noise emissions, vibrations, fuel consumption and, thus contribute to the reduction of operational pollution by making the various transport means more environment-friendly, particularly in the road, sea and aviation sectors.

The wide-spread use of electric vehicles for both goods and passenger transport and of hybrid (fuel/electricity) buses in cities and towns should affect atmospheric and noise pollution in the urban environment. On a more global scale a switch to electric vehicles should affect dependency on oil supplies.

57. In the case of road transport environment-friendly and safe speed limits for road vehicles according to the type of vehicle, road and the specific traffic environment will contribute to the reduction of noise and vibrations as well as fuel consumption and gaseous emissions, particularly CO<sub>2</sub>.

58. Effective implementation and enforcement of these standards will require continuous periodical checking in order to ensure that they are not infringed.

This can be achieved by the introduction of environmental criteria in road and air worthiness testing of all vehicles, including motorcycles, and aircraft as well as the use of technical devices, such as speedlimiters, to ensure compliance with imposed speed limits.

These standards will also require continuous updating in order to ensure that they keep up with technological and technical progress and thus continue to meet the objective of "best available technology".

59. This will be furthered by the promotion of research and development for the improvement of the environmental performance of the different transport modes and infrastructure as well as the promotion of new energy technologies such as bio-energy and electricity-driven vehicles. This in turn can be achieved by encouraging funding and providing fiscal incentives for specific R & D projects.

60. The introduction of new standards and deadlines for implementation should provide the opportunity to present "target" values and dates for industry. At the same time fiscal incentives should encourage the user and the operator to opt for the technically most environment-friendly vehicle, aircraft, vessel, motorcycle, train and fuel before the "target date."

"Targets" can be set in such a way that legislation provides an incentive for industry to keep up with technological and scientific progress, while the "guided" choice of the user and operator can put pressure on industry to meet these "targets".

**b. Land-use and intrusion**

61. Transport infrastructure has a permanent and often irreversible impact on the environment in terms of land-use and land intrusion. The impact of land-use varies according to the scarcity of land. Thus, infrastructure will not have

the same impact in the urban environment as it does in less densely populated rural areas.

In highly populated areas infrastructure can cause obstacles to the mobility of pedestrians, isolate physically as well as socially sections within the larger urban area, create visual barriers, exacerbate existing traffic nuisances and disturbances and disrupt day-to-day social and commercial activities.

62. Transport infrastructure also determines the development of the urban and suburban landscape, influences the social and architectural homogeneity of cities and towns, reduces available living space and "green" belts.

Transport infrastructure encroaches on the landscape : it can disrupt or destroy natural habitats as well as cause permanent damage to areas of high landscape value, leading to a deterioration in the ecological balance with particular significance for the wildlife.

63. There are no comprehensive data available on the land taken up by the infrastructure of the different modes of transport in the Community. However, on the basis of the length of the different infrastructure networks, it is nevertheless possible to work out a broad estimate of the land-use<sup>(1)</sup> for each transport mode.

According to Eurostat in 1986 the Community road network consisted of 30,237 km of motorways and 2,549,907 km of other roads, the rail network of 70,911 km of single track lines and 54,918 km of double track lines and the inland waterway network (including natural waterways) consisted of 21,634 km.

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(1) Assumptions concerning the average width of  
- Roads : 11.22m  
- Railway lines : 5.61m  
Forward Studies Unit, Transport and the Environment, op.cit.,  
p. 24.

64. The Community road network would thus take up a surface area of 28,949 km<sup>2</sup> or 1.3% of the total land area of the Community. This does not include the surface area used for intersections and junctions nor car parks. The parking space for a single car in purpose-built ground level car parks can be as much as 17 m<sup>2</sup>(1) (including the space needed for turning and driving).
65. For the Community railway network the corresponding figures are 706 km<sup>2</sup> or 0.03% of the total land area of the Community. These figures do not take into account land used for railway stations and marshalling yards. A capacity comparison for commuter traffic during the rush hour shows that a double track railway line can move the same number of people (± 6500 passengers) per hour as a motorway.(2)
66. It is not possible to estimate the land-use for inland waterways since there are no data available for the average width of the different types of canals and the inland waterway networks in the Community also includes natural waterways such as rivers and streams. There are no global figures available on the land-use for airports in the Community. However, the land-use for an airport can range from 200 to 400 ha for the smallest regional airports to 1500 to 2000 ha and over for hubs(3). A few examples illustrate this : Paris-Orly 1500 ha, Brussels-Zaventem 1600 ha, Amsterdam-Schiphol 1800 ha and Paris-Roissy 3100 ha.

#### *Limitation of land intrusion*

67. In order to limit land intrusion of infrastructure it will be necessary to ensure full use of existing infrastructure capacity as well as plan strategically expansion of existing

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(1) CEC, Policy and Provision for Cyclists in Europe, Brussels, 1989, Annexe 2, p. 20.

(2) Fondation Roi Baudouin, Mobilité, transport et environnement, Bruxelles, Janvier 1991, p. 86.

(3) Mens en Ruimte, Etude thématique du projet TGV, Bruxelles, décembre 1989, p. 19.

infrastructure networks. It will also be necessary to limit the increase in transport demand, particularly in encumbered sectors.

68. This can be achieved by

- . efficient and optimal use of existing transport capacity
- . traffic management schemes which spread more evenly the flow of traffic, particularly in the road and aviation sectors
- . coordination of infrastructure planning and regional development, taking account of the impact on the environment
- . strict implementation and follow-up of the environmental impact assessment of new projects, policies, plans and programmes which affect transport demand
- . conversion of relinquished infrastructure for the use of "soft" transport.

69. Market organisation should allow for efficient and optimal use of existing transport capacity and thus encourage a shift from encumbered sectors to sectors where there is excess capacity, particularly from road to rail, combined transport and inland waterways for goods and from private car to collective transport for persons. Infrastructure planning should be coordinated in order to contribute to that objective.

70. Full implementation of the freedom to provide services and the elimination and prevention of distortions of competition, in accordance with the objectives of the Treaty, together with the introduction of environmental charges or taxes related to operational pollution should contribute to a more balanced distribution of the existing volume of traffic between the different transport sectors. This in turn should reduce existing pressure on infrastructure capacity in the most encumbered sectors.

c. Congestion

71. "Congestion" is a recurrent temporary phenomenon of variable duration, caused by an imbalance between the demand for and supply of transport infrastructure capacity, which results in an overburdening of existing capacity. Congestion is characteristic of urban traffic and more recently of air traffic.

The most important consequences of congestion include reduction of capacity and mobility, increase of energy consumption and operational pollution, inefficient use of time. It can also cause a loss of comfort and personal wellbeing, a drop in income, production or leisure.

72. Available data on the social and economic cost of road congestion indicate a cost of £10 to 15 billion per year in Great Britain<sup>(1)</sup> and of 1 billion guilders for the Netherlands. By the year 2010, with a 70% increase in car use, the cost of congestion in the Netherlands could be as high as 4 billion guilders<sup>(2)</sup>.

In aviation the costs of congestion in Europe have been estimated at US \$1,510 million for the year 1988. These figures include for the airlines increased operating expenses (additional fuel, salaries for crew and other personnel, maintenance, excess interest, ...) and increased fleet size cost as well as the costs to airline passengers in terms of value of lost time<sup>(3)</sup>, with considerable repercussions for the tourist industry.

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- (1) PIARC-Technical Committee on Roads in Urban Areas, Reduction of Car Traffic in City Centres, Pre-Congress Report, Marrakesh 1991, p. 8.
- (2) Second Chamber of the States-General, Session 1989-1990, Second Transport Structure Plan, part d : Government Decision, Transport in a Sustainable Society, p. 5.
- (3) Planingsbüro Luftraumnutzer : The German Airspace Users Association, The crisis of European air traffic control : Costs and Solutions, p. 26-27.

Fuel consumption in the aviation sector is linked to technology and flying conditions (load factor, flight profile, weather conditions, congestion). As shown in figure 5 fuel consumption is mainly determined by flying conditions of which waiting before take-off, holding before landing and taxiing after arrival are due to congestion.

73. A supply-side solution to the problem of congestion does not necessarily restore the medium and long term capacity balance and does not, therefore, necessarily reduce the effects of the phenomenon. Congestion in the road sector, for example, can represent a useful tool of dissuasion, since the available time-budget of the road user might lead him/her to seek more efficient alternatives in the form of collective transport.

*Reduction of congestion*

74. Traffic and congestion are interrelated phenomena. Changes in the volume of traffic will affect congestion.

Traffic reduction will require a drop in transport demand and/or improved occupancy. This can be achieved by a more environmentally rational approach towards mobility for both goods and persons and will require changes in the mobility patterns of users and operators

Urban and industrial planning can contribute to changes in mobility patterns as can the wide-spread use of telecommunications. Emphasis on proximity and accessibility should contribute to traffic reduction and encourage the use of so-called "soft" means of transport, cycling and walking.

75. The road and aviation sectors are the most sensitive to congestion.

In the road sector large conurbations and access routes to large conurbations are most affected by excessive traffic, particularly during so-called peak times. Congestion can be reduced by

- . adequate collective transport systems
- . high occupancy rate
- . traffic management schemes
- . road pricing
- . reduced accessibility to congested areas for motorcars.

76. Such measures should contribute to the reduction of the volume of traffic as well as to the improvement of its fluidity. Their effects can be reinforced by transport policy measures which encourage a shift towards collective transport, particularly for urban and inter-urban traffic and more specifically during certain periods of the day and certain times of the week and year. This shift will be made easier by a proper link-up of the different stages of a journey : from point of departure (home/office) to metro/bus stop to train station/airport to metro/bus stop to final destination.

77. In the aviation sector hubs are particularly sensitive to excessive traffic. Congestion can be alleviated by

- . efficient air traffic control systems
- . regional distribution of traffic
- . seasonal distribution of holiday travel
- . rational use of aviation and airport capacity
- . best-in-class performance of airports.

The availability of highspeed train services can serve as an alternative to short haul flights and, thus, contribute to reducing airport congestion.

78. A reduction in traffic will contribute to the reduction of operational pollution as well as congestion and its side-effects. It will also reduce the pressure on existing infrastructure capacity, particularly in the road and aviation sectors. Its effects will be most far-reaching for the urban environment.

79. In the case of congestion, particularly in urban and suburban areas, infrastructure planning should not necessarily seek to promote an increase in capacity, since in certain instances this might boost transport demand and in the long-term exacerbate the problem, particularly in the case of road transport. However, adequate link-ups between the infrastructure networks of the different modes might contribute to solving the problem of congestion in certain instances by making alternative transport more accessible.

**d. Risks inherent to the transport of dangerous goods**

80. The release of certain chemical substances can cause air, water and soil pollution with extremely harmful effects for human life as well as animal and plant life. The carriage of such goods, thus, represents a risk for the environment.

A transport accident involving dangerous or polluting goods, including dangerous biological agents, genetically modified organisms or micro-organisms, can cause major environmental damage if these goods are discharged into the environment. The damage will depend upon the nature, characteristics and volume of the substances thus released.

81. Transport accidents involving dangerous or polluting goods can affect the ecosystem of water, soil and air with long term direct and indirect effects for human, plant and animal life.

Technical failure in a vehicle can have out-of-proportion effects as was illustrated in 1983, when due to brake failure, a 10t lorry carrying a load of dangerous chemicals crashed into several vehicles in the vicinity of Huy (Belgium). This caused the discharge of corrosive liquids into the environment and resulted in five deaths, 21 injured, four burnt cars and extensive damage to buildings and the environment.

82. Accidents at sea, such as those of the Amoco Cadiz and the Torry Canyon, can lead to major disasters for the marine environment. The Exxon-Valdez accident in 1989 resulted in a spill of 10.8 million gallons or 35,000 tonnes of oil with major and long lasting effects on the marine environment as well as on plant and animal life along the coast. The actual damage to fisheries, water, wildlife and land is estimated by American sources between 2.5 and 5 billion U.S.\$.

Other dangerous goods can have equally damaging effects, particularly in the case of toxic, explosive or radioactive materials.

*Reduction and prevention of risks inherent to the transport of dangerous goods*

83. In order to prevent and reduce the risks inherent to the transport of dangerous goods, it will be necessary to make this type of transport safer and allow for immediate and appropriate intervention in the case of accidents.

This will require

- . Minimum requirements for the safe carriage of all types of transport of dangerous goods.
- . Special training requirements for those in charge of the transport of the goods.

- . Uniform marking of all dangerous goods for all types of transport.
- . Introduction and use of telematics for transport management of dangerous goods.
- . Comprehensive safety instructions for the handling of the goods during their transport.
- . General safety requirements for the packaging of dangerous goods and for the means of transport.
- . General transport safety measures, particularly in the road and maritime sectors, including safe speed limits for commercial vehicles carrying dangerous goods as well as the use of speed limiters.

Such measures should prevent risks and reduce or contain the potential harmful effects in the case of transport accidents.

**e. Conclusions of assessment**

84. The assessment of the impact of transport on the environment according to its operational pollution, the impact of transport infrastructure on space, the consequences of congestion and the risks linked to the carriage of dangerous goods has shown that the impact differs for each transport sector.

- . Operational pollution is the key component for all transport sectors, but more particularly for the road, sea and air sectors.
- . Land-use ranks as second, particularly in the road and railway sectors.

. Congestion, although important, constitutes a secondary factor which exacerbates operational pollution and puts pressure on existing infrastructure capacity. It is particularly important in the case of road and air transport and in the case of road transport the effects are heightened in the urban environment.

. The risks inherent to the carriage of dangerous goods constitute an important potential impact on the environment. This aspect of the impact is linked to the volume of dangerous goods carried by a particular transport sector.

85. The impact of all transport sectors includes in different degrees these four components.

. Operational pollution, land-use, congestion and risks inherent to the transport of dangerous goods together as well as individually rank highest for road transport.

. Land-use in the case of sea and air transport is of a totally different nature to that of road and rail transport. This in turn affects the nature of congestion and the way it can be controlled.

#### IV. ECONOMIC TRENDS

##### a. Trends and forecasts

86. The size and scale of the impact of transport on the environment is a function of the volume of transport and the activities of each transport sector. Therefore, it is essential to analyze the factors which determine transport demand.

Transport demand - both for freight and passengers - in general reflects the level of economic activity.

87. Since 1970 the annual economic growth in the Community has averaged 2.6% in real terms. Economic forecasts expect this trend to continue until at least the end of the century.

For the period 1970-1988 the overall annual growth in inland transport averaged 3.1% for passengers and 2.3% for goods. This growth was not spread evenly between the different sectors. Thus, the increase in road transport both in absolute and relative terms has been much higher than for the other inland transport sectors (see figure 6). Since 1980 the increase in air passenger transport has been highest of all with an average growth rate of 6.1% per year. (see tables 7 and 8). The growth in tourism has contributed to this trend .

88. The completion of the Single Market together with the creation of the European Economic Area, the political and economic developments in Eastern Europe as well as Economic and Monetary Union will influence the level of socio-economic activity in the Community in the short and medium as well as the long term. The expected increase in economic activity, as well as in intra-Community and external trade is likely to boost transport demand. (see Table 9)

89. In the "business as usual" scenario (1) road transport in the Community will continue to increase significantly.

Road haulage is expected to increase by 42% between 1990 and 2010, from 805 to 1.139 billion tons-km by 2010, whereas rail transport should only increase by 33% during the same period.(1)

90. Although the total population of the Community will remain stable until the year 2010, demand for passenger transport will be influenced by changes in the demographic environment, including the size of the workforce, the share of female participation in the workforce, the size and number of households, the age structure, the lengthening of active retirement.

The stock of private cars should increase by 45% from 115 million in 1987 to 167 million by 2010, leading to a car ownership of 503 cars per 1000 inhabitants by 2010 against 381 at present.(1)

91. The specific fuel consumption of cars should improve from 9.3 l/100 km at present to 7.8 l/100 km by 2010. The average annual mileage per car should decrease from 14,400 km/year in 1990 to 13,400 km/year by 2010, but the total car mileage should increase by 25% between 1990 and 2010, from 1,727 billion km in 1990 to 2,166 billion km in 2010.(1)

In the same scenario passenger transport by air is expected to increase by 74% between 1990 and 2010.(1)

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(1) Energy in Europe, Energy for a New Century. The European Perspective, Special Issue, Brussels, July 1990, Technical Annex.

b. Structural changes

92. Over the last two decades the economy has been undergoing a number of major structural changes, with far-reaching consequences for transport demand. Transport prices, which so far have not reflected all external and internal costs, have contributed to these changes.
93. Firstly, the structure of industrial production has been shifting from basic industry towards high-technology production of high value/low volume goods. Moreover high-technology industry in the Community is undergoing a geographical shift towards the so-called "new industrial spaces" in Southern Europe.
94. The ever growing importance of the service industry is another major structural change. The service sector represented 58% of total GDP in the Community in 1985. This share is expected to go up to 66% by the year 2000. The trend is to concentrate new service activities in the core regions of the Community, where they will put further pressure on the already congested transport networks.
95. Manufacturing technology is also undergoing rapid and radical changes. The "Just-in-time" methods of inventory management are leading to smaller and more frequent shipments, shorter lead times and an increase in door-to-door deliveries. The more versatile customer-orientated production methods also result in more frequent deliveries of smaller shipments. Transport demand is, thus, becoming more sophisticated and more specialised.
96. The improvement of communication networks has in turn lead to a wider geographical dispersal of economic activity and more sophisticated and more versatile production systems. The trend

towards sub-production, as for example in the motor-car industry, is leading to a large number of interplant flows of commodities and personnel. Data communications make it further possible to separate the so-called "back-office" routine work from central management activities.

97. These structural changes have furthered the changes in scale and size of undertakings, in the siting, the range and nature of operations, which in turn have resulted in a concentration of production in the most favourable locations.

All these factors affect the demand for goods transport, shifting the emphasis from volume to frequency and speed, boosting total tonnage, average distances and shipment frequency as well as speed, but reducing average shipment size. The qualitative aspects - speed, reliability, frequency, flexibility - are thus gaining in importance.

c. The user's choice

98. The analysis by a consultant<sup>(1)</sup> of the different factors which determine the choice of transport mode and their relative importance provides the following evidence on the user's choice of transport mode.

*"Freight"*

99. For the transport of goods the user's choice is based on a number of criteria, including
- . the value/weight ratio of the commodity
  - . the cost of transport including terminal, transshipment and line-haul costs
  - . the speed and reliability of delivery

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(1) Erasmus Universiteit Rotterdam, Factors Influencing Mode Choice, final report, Rotterdam, September 1991.

- . the quality of service, including safe transport of the goods
- . the administrative efficiency and availability of information on the whereabouts of goods
- . the distance and door-to-door Journey time (including loading/unloading time)
- . the available alternatives
- . availability of and access to infrastructure
- . the availability of related services (packaging, distribution, ...).

100. The transport of goods, however, needs to be viewed as an integral part of the logistics of the production and distribution process. The logistics may vary for the different stages in the goods flow, depending primarily upon the nature of the goods.

- (i) For raw materials, transport is usually "point to point", generally between a limited number of suppliers and customers. It is predominantly by road and inland waterways, rail taking up only a small share of the market. Transport costs constitute the determining factor in the user's choice.
- (ii) For semi-finished products, transport is usually "convergent", generally between a large number of suppliers and a small number of large customers. The transport service is predominantly by road, the logistics being those of "just-in-time". Speed and reliability of delivery are the key elements in the choice of mode.
- (iii) For finished products, transport is usually "divergent", between a large number of suppliers and customers. It is predominantly by road and to a lesser extent by air. A

combination of quality of service, speed and reliability as well as the availability of related services determine the choice of mode.

- (iv) For consumer goods, transport is usually "very divergent", between a large number of suppliers and customers. The service is predominantly by road. Speed and reliability are the key factors in the choice of mode.

*"Passengers"*

101. The user's choice in the case of passenger transport is influenced by three sets of factors : the characteristics of the different modes, the socio-economic status of the decision-maker, the nature of the journey.

- (i) The characteristics of the different modes include the travel time and the monetary cost.

\* The travel time is usually divided into two components : in-vehicle time and out-of-vehicle time. The out-of-vehicle time spent on waiting and walking is often rated as more uncomfortable and inconvenient than in-vehicle time.

\* The monetary cost is usually the out-of-pocket cost (fare for public transport, petrol costs, tolls and parking charges for private cars). Fixed costs such as depreciation and interest charges, insurance, annual road tax appear to have little or no effect on the user's short-term choice.

Other determining characteristics are transparency of the system, physical comfort, safety, status, punctuality.

- (ii) Income, age, sex, lifecycle stage of the household, occupation, education, possession of driving licence, car ownership and residence are the main elements of the socio-economic status of the decision-maker which influence his/her choice.

For physical, economic or social reasons, certain groups of individuals may be more sensitive than others to specific characteristics of the transport mode. Thus, low income agents respond more readily to travel costs, working mothers to travel time, etc...

- (iii) The nature of the journey is characterised by the travel purpose (work, study, shopping, social visit, holiday, ...), distance, time of departure and arrival, day of the week, season, time of the year. Certain characteristics of the mode of transport may be more important for certain types of journeys : for work and business journeys travel time and reliability are more important than monetary costs.

102. The user's choice, however, is subject to a number of constraints of which the most important are the availability of specific modes and the awareness of alternatives. The key element in the decision process appears to be the availability of a motor vehicle. Habit and lack of information about alternative modes may prevent a person from switching from private car to rail, bus or underground, especially in the short-term. Evidence, however, suggests that the wide availability of effective and reliable information about collective transport can influence the user's choice in the long term.

It is also important to note that the availability of a motor vehicle affects the mobility pattern of the user in terms of the frequency and distance of the journeys : users with easy access to cars cover more than four times the mileage of those without cars.

V. A COMMON STRATEGY

a. A global approach

103. The assessment has shown that transport is never environmentally neutral. Thus, since existing trends indicate that transport and traffic, particularly in the road sector, will continue to grow over the next decades and that the demand for transport services, all things being equal, will increase, the impact of transport on the environment will become more significant. It is, therefore, essential that the Community adopt a Common strategy, which aims to reduce or at least contain the overall impact of transport on the environment in a global and coherent manner.

104. Such a strategy will require a global approach in order to ensure that transport continues to fulfil its economic and social functions under the most favourable environmental conditions, while safeguarding the freedom of choice for the user. A global approach should also ensure that it contributes to social and economic cohesion in the Community and to the prosperity of the peripheral regions.

Moreover, a global approach should ensure that the strategy covers all aspects of the impact and, thus, reduces operational pollution, slows down unnecessary transport demand, reduces traffic and congestion and promotes efficient use of existing transport and infrastructure capacity, guarantees safer transport of dangerous goods and reduces pressure on the infrastructure capacity of the most encumbered sectors.

105. A strategy based on a global approach would promote '*sustainable mobility*' by integrating transport into an overall pattern of sustainable development which would seek to "meet the needs of the present without compromising the ability of future generations to meet their own needs"<sup>(1)</sup> and

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(1) The World Commission on Environment and Development, "Our Common Future", 1990, p 43.

would, thus, be in line with the objectives and targets of the forthcoming Fifth Action Programme : A new Strategy for Environment and Development - "Towards Sustainability".

106. The Commission is aware that adequate protection of the environment is not possible by reliance only on technological progress and technical measures. Evidence of this is given by the Commission Communication of September 1991, "A Community Strategy to Limit Carbon Dioxide Emissions and to Improve Energy Efficiency"<sup>(1)</sup>.

This strategy presents a wide range of measures and initiatives, including the need to study the possibility of a new fiscal instrument in the form of a CO<sub>2</sub>/energy tax applicable to all non-renewable energy. Given the low price elasticity of demand for private road transport the proposed CO<sub>2</sub>/energy tax will require in the transport sector additional policy measures, both regulatory and economic.

107. The same approach is adopted for urban transport in the Green Paper on the Urban Environment<sup>(2)</sup> where it is recognised that environment-friendly vehicles would bring some relief, but that it is also necessary to initiate a significant shift in the balance between transport modes, favouring public over private transport and reducing the level and impact of motor traffic in inner cities.

108. A strategy based on a global approach will thus require different kinds of initiatives : standardization, market organization and cost-charging measures as well as research initiatives.

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(1) SEC (91) 1744 final

(2) [Com(90)218 final of 27 June 1990]

b. Balance sheet of Community action

109. The Community has already to a large extent been guided by the principles of 'sustainable mobility'.

(1) "Standardisation measures"

110. A large number of standardisation measures have already been adopted in order to ensure a better environmental performance of the different transport means as well as the safer carriage of dangerous goods.

They include

- . gaseous emission standards for petrol and diesel engines
- . noise standards for aircraft, motor vehicles and motor cycles
- . standards for sulfur content of diesel fuel
- . air quality limit values and guide values for sulfur dioxide, and suspended particulates and air quality standards for lead and nitrogen dioxide
  
- . harmonisation of weights and dimensions for heavy goods vehicles
- . introduction of ABS systems for heavy goods vehicles and trailers
- . introduction of speed limiters for certain types of heavy goods vehicles and buses
  
- . training requirements for drivers of lorries carrying dangerous goods
- . notification procedure for ships carrying dangerous goods in bulk
- . notification procedure for the transfrontier shipment of hazardous wastes within the Community

- . mandatory environmental impact assessment for infrastructure projects
- . mandatory availability of unleaded fuel.

111. The Commission has supplemented the existing Community legislation with additional proposals.

These include

- . updating of gaseous and noise emission standards for motor vehicles
- . standards for railway noise
- . checking of gaseous emissions in road worthiness test
- . extension of environmental impact assessment
  
- . extension of notification procedure to ships carrying dangerous and polluting goods in containers, tankers, tanker-lorries
- . obligation to designate a risk prevention officer for the transport of dangerous goods.

*(11) "Market organisation measures"*

112. The Community has already adopted a number of market organisation measures which introduce the freedom to provide services in the transport sector as well as measures which aim to eliminate or prevent distortions of competition in order to achieve a better utilisation of existing transport capacity.

These include

- . access to intra-Community road haulage and road passenger transport
- . limited cabotage in the road sector
- . cabotage in the inland navigation sector
- . limited access to railway infrastructure and market
- . access to regional airports
- . reduced constraints on access, fares and capacity in the aviation sector

- . coordination of scrapping schemes for inland navigation
- . freedom to provide maritime services
- . state aid measures for combined transport
- . Community financing of infrastructure projects.

113. The Commission has submitted to the Council additional market organisation measures.

These include

- . extension of cabotage in maritime transport and the road sector
- . further reduction of constraints on access, capacity and fares in the aviation sector.
- . improvement of competitive position of railways.

*(III) "Cost-charging measures"*

114. The Commission has already proposed measures which take better account of the external costs of transport.

These include

- . infrastructure charging for heavy goods vehicles
- . harmonisation of excise duties on mineral oils.

Also, the 1991 Commission Communication "A Community strategy to Limit Carbon Dioxide Emissions and to Improve Energy Efficiency" includes a chapter on fiscal measures which refers to

- . the possible use of tax differentiation for vehicle taxation so as to take account of the impact of motor vehicles on the environment (gaseous emissions, noise,...)
- . the possible introduction of a tax on CO<sub>2</sub> emissions and the use of non-renewable energy in order to contribute to the reduction of the "greenhouse effect".

**(iv) "Research Initiatives"**

115. A number of actions and research projects covering certain aspects of the environmental impact of transport have already been initiated.

These include

- \* **BRITE/EURAM** (Basic Research in Industrial Technology for Europe & European Research in Advanced Materials) : R & D programme to strengthen the competitiveness of the European manufacturing industry in world markets and to establish the necessary technological base for the development of new products and processes.
- \* **CORINE** (Coordination of Information on the Environment) : programme to collect information on the levels and sources, including road transport, of air pollution.
- \* **COST** (European Cooperation in the field of scientific and technical research) : framework for research cooperation, including projects on environment-friendly vehicles (COST 302, 303)
- \* **DRIVE** (Dedicated Road Infrastructure for Vehicle Safety in Europe) : R & D programme to develop and validate tools and strategies for demand management, to reduce congestion, to improve road safety, road transport efficiency and the environmental impact of road transport through the application of transport telematics.
- \* **EURET** (Specific Research and Technological Development Programme in the field of Transport) : research programme to optimize network exploitation and transport logistics and to reduce harmful externalities.

- \* **JOULE** (Joint Opportunities for Unconventional or Long Term Energy supply) : R & D programme to develop energy technologies that take account of new and renewable energy sources, to increase security of supply and reduce energy imports and to contribute to environmental protection, including reduction of CO<sub>2</sub> emissions.
  
- \* **SAST** (Strategic Analysis in Science and Technology) : programme to identify, amongst others, the extent to which technological development can contribute to the reduction of the impact of transport on the environment.
  
- \* **SAVE** (Specific Action of Vigorous Energy Efficiency) : programme of energy conservation measures, amongst others, in the transport sector.
  
- \* **STEP** (Science and Technology for Environmental Protection) : R & D programme to provide scientific and technological support for the environmental policy of the Community and to promote the quality of environmental research.
  
- \* **THERMIE** (Promotion of European Energy Technologies) : programme to promote innovative energy technologies, dissemination and market penetration of energy technologies, to encourage greater use of new and renewable energy sources and to improve energy efficiency and environmental protection.

c. *"Sustainable mobility"* and future transport development

116. These measures and initiatives go some way towards resolving the areas of conflict between transport and the environment. However, on their own, in view of the expected growth in transport demand and traffic, they will not suffice.

The gains achieved through technical standardisation, the freedom to provide services and the elimination of distortions of competition are likely to be overtaken by the overall increase in mobility due to the growth in economic activity.

117. Even if the 'acquis' were to be supplemented by the introduction of the 'best available technology' and the strictest possible environmental standards for noise and gaseous emissions, fuel efficiency, fuel quality and alternatives as well as measures to enforce and check their implementation, the gains thus achieved could easily be offset by the growth in traffic and congestion as illustrated under point 91.
118. A Common strategy for '*sustainable mobility*' will require additional initiatives.

Such initiatives should focus on

- . market organisation measures which further the freedom to provide services and the elimination of distortions of competition, while aiming more specifically at encouraging the more environment-friendly modes as well as efficient use of existing capacity
- . additional risk prevention measures in order to ensure safer carriage of dangerous goods
- . traffic management schemes in areas most vulnerable to congestion and the introduction of advanced telematics to improve efficiency of transport operations
- . the use of fiscal and economic instruments in order to influence the user and operator's choice in favour of cleaner technology and the more environment-friendly transport modes.

119. In order to reinforce these initiatives public and private investment should be guided towards collective transport, whereas urban, industrial and commercial as well as regional development planning should be geared towards reducing the need for mobility. At the same time infrastructure planning should be made subject to restrictions on land intrusion as well as to strict environmental impact assessment procedures at both the strategic and project stages, including evaluation of alternative options.
120. Coordination of such measures and initiatives will be essential as will their adaptation to the characteristics of the different transport sectors. At the same time it will also be necessary to ensure that any interaction of the effects resulting from the different measures should remain compatible with the overall objective while allowing for economic efficiency and commercial viability of transport and the freedom of choice of the user and operator. It will also be necessary to take due account of the possible effects on small and medium size undertakings. Equally important will be the need to ensure that the peripheral regions share in the prosperity of the Single Market.

*"The role of the user and operator"*

121. A key element in any strategy which is to prove effective will be the behaviour of the user and operator.

Given the dominance of road transport, its impact on the environment and the expected growth in the volume of road traffic, it will be essential to influence the behaviour of the road user, particularly the private car owner.

As shown above the key factor in the decision-maker's choice of mode is the availability of a motor vehicle, which in turn affects the mobility pattern of the user. This becomes all the

more important in view of the expected growth in car ownership which could be as high as one car for every two citizens in the Community by the year 2010.

122. A strategy which seeks to influence human behaviour towards mobility will need to focus on the attitude of the user towards the car.

The user should, thus, be encouraged to opt for an environment-friendly and energy efficient vehicle, alternative modes of transport, including "soft" means of transport, as well as a rational use of the motor car.

123. This could be achieved by fiscal incentives, efficient and accessible collective transport, restricted vehicle access, limited parking facilities in city centres but strategically placed car parks allowing for adequate link-up with collective transport, integrated urban and suburban planning and improved facilities for "soft" users.

Such actions would be more effective if reinforced by information, public education and public awareness campaigns.

124. The user is also a consumer and as consumer should be given adequate and accurate information about the environmental performance of vehicles so that an environmentally rational choice is possible.

125. As seen above the user's choice, when it comes to the transport of goods, is influenced by a number of criteria of which in the majority of cases speed and reliability are the most important. This to a large extent determines the user's choice of operator.

In order to encourage more environment-friendly transport of goods it will be necessary to off-load the increase in demand from the road onto other sectors by providing alternatives equally attractive to road haulage.

This will require more efficient rail services for goods, better access to combined transport and improved transshipment facilities, improved quality of service and reliable door-to-door travel time for inland navigation and coastal shipping.

126. At the same time the operator should be encouraged and in some instances compelled to opt for the technically "clean" vehicle, aircraft, barge, ship and train and make full use of existing transport and infrastructure capacity. Fiscal and economic incentives as well as general and selective restrictions on access to infrastructure can contribute to this, as well as reduce the demand for transport.

d. A new framework

127. Although the Community has recognised the need for a coherent and global approach to the impact of transport on the environment, there is as yet no framework for a Common strategy aimed at '*sustainable mobility*' in the Community.

Such a framework will require coordinated examination of

- . measures laying down strict environmental standards for motor vehicles, motorcycles, aircraft, barges, ships, trains and fuel quality as well as measures to enforce and check their implementation
- . environmental measures laying down strict air and water quality standards as well as strict limit values for air and water pollutants supplemented by measures to check and enforce their implementation
- . transport policy measures which implement the objectives of the Treaty as well as Community policies adopted to fulfil these objectives and ensure efficient and optimal use of existing transport capacity for the different modes, allow

environment-friendly modes, such as railways, inland and sea navigation and combined transport, to compete with road and aviation and ensure that transport contributes to CO<sub>2</sub> stabilisation in the Community

- . an overall action plan for the transport of dangerous goods which will ensure that these goods are carried in the safest possible manner throughout the Community
- . fiscal and economic instruments and a framework for the use of such instruments by the Member States in the transport sector in order to promote environment-friendly transport and ensure that external costs are included in the price of transport
- . guidelines for the development and assessment of Community infrastructure projects which would discourage unnecessary transport demand and encourage where appropriate the development of alternatives to road transport, such as railway, inland waterways and combined transport as well as urban and inter-urban collective transport
- . guidelines for the conversion and upgrading of relinquished infrastructure, particularly for the purpose of 'soft' transport
- . guidelines for the development of urban transport which give priority to collective and 'soft' transport and to adequate link-up between the different stages of urban journeys as well as to easy access to and from inter-urban transport
- . guidelines for 'soft' tourism which promote the use of environment-friendly transport
- . guidelines for the development of Community research programmes which promote the development of 'clean' transport technology and the marketing of environment-friendly fuels, such as bio-fuels (ethanol, rape seed

diester, etc...), natural gas and electric vehicles, including hybrid (fuel/electricity) buses as well as the development of efficient traffic management schemes

- . minimum consumer information requirements concerning the environmental performance of motor vehicles
- . guidelines for information campaigns on the environmentally rational use of the private car which draws the attention of the user to environment-friendly alternatives such as collective and 'soft' transport.

128. The results of this examination should provide the framework for a Common strategy of '*sustainable mobility*', which should contain the impact of transport on the environment, while allowing transport to continue to fulfil its economic and social functions, particularly in the context of the Single Market, and thus ensure the long term development of transport in the Community. It should also contribute to social and economic cohesion in the Community and to the creation of new opportunities for the peripheral regions.

While safeguarding the freedom of choice for the user, this framework should identify, in accordance with the principle of subsidiarity, the responsibility which the different actors will have to assume in order to achieve the objective of the strategy.

129. The purpose of this Green Paper is to initiate a public debate on the issue of transport and the environment and the proposed strategy for "*sustainable mobility*". This should involve the views of the Council of Ministers, the European Parliament and the Economic and Social Committee as well as those of the social partners. The debate should also draw views from

international organizations and associations and a response from the general public, including industry, transport users and operators, environmental protection groups, regional and local authorities.

The outcome of the debate should provide an insight into the way in which it will be possible to achieve the objectives of "*sustainable mobility*" and how, according to the principle of subsidiarity, the different actors are to contribute to the strategy. It should also provide a blueprint for the forthcoming White Paper on the Future Development of Transport Policy.

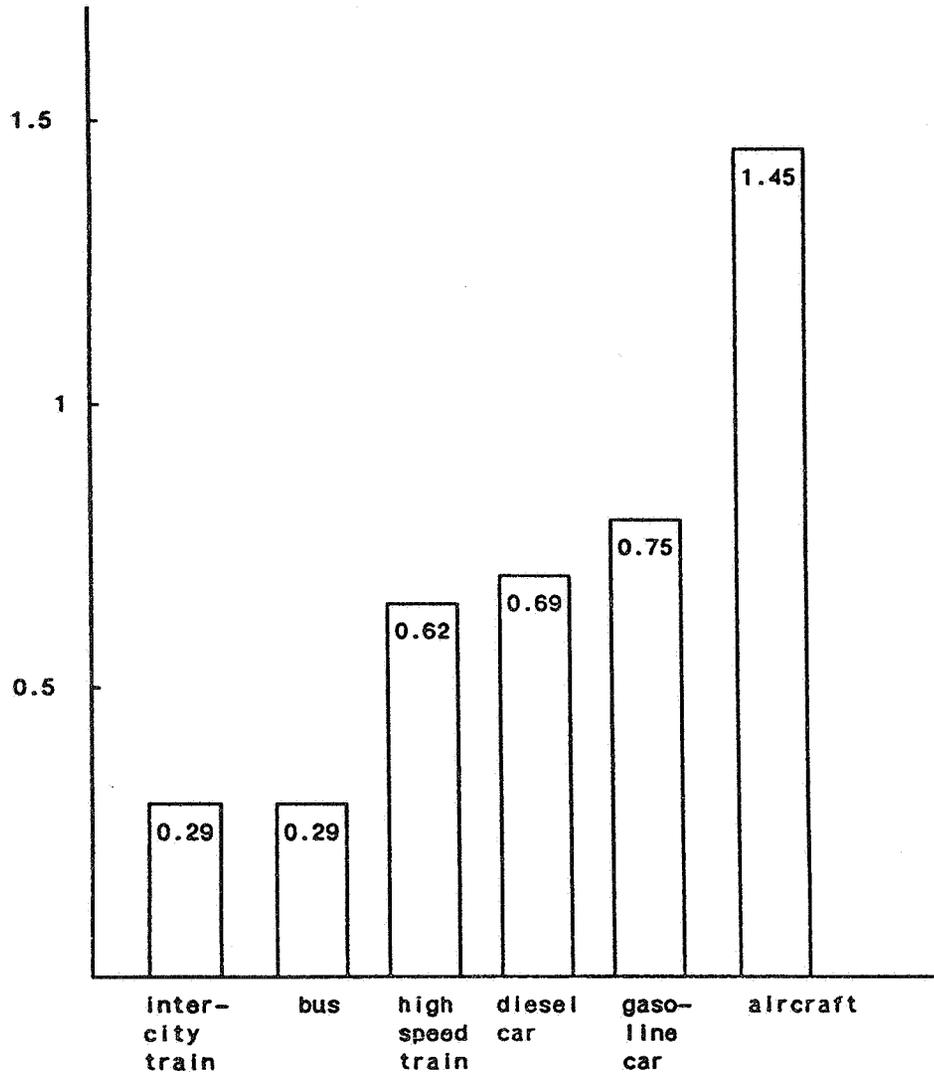
\* \*  
\*

**Figure 1**

**SPECIFIC ENERGY CONSUMPTION OF DIFFERENT MEANS OF TRANSPORT**

*Passengers*

MJ  
primary  
energy/  
passenger-km  
(100 % occupancy)

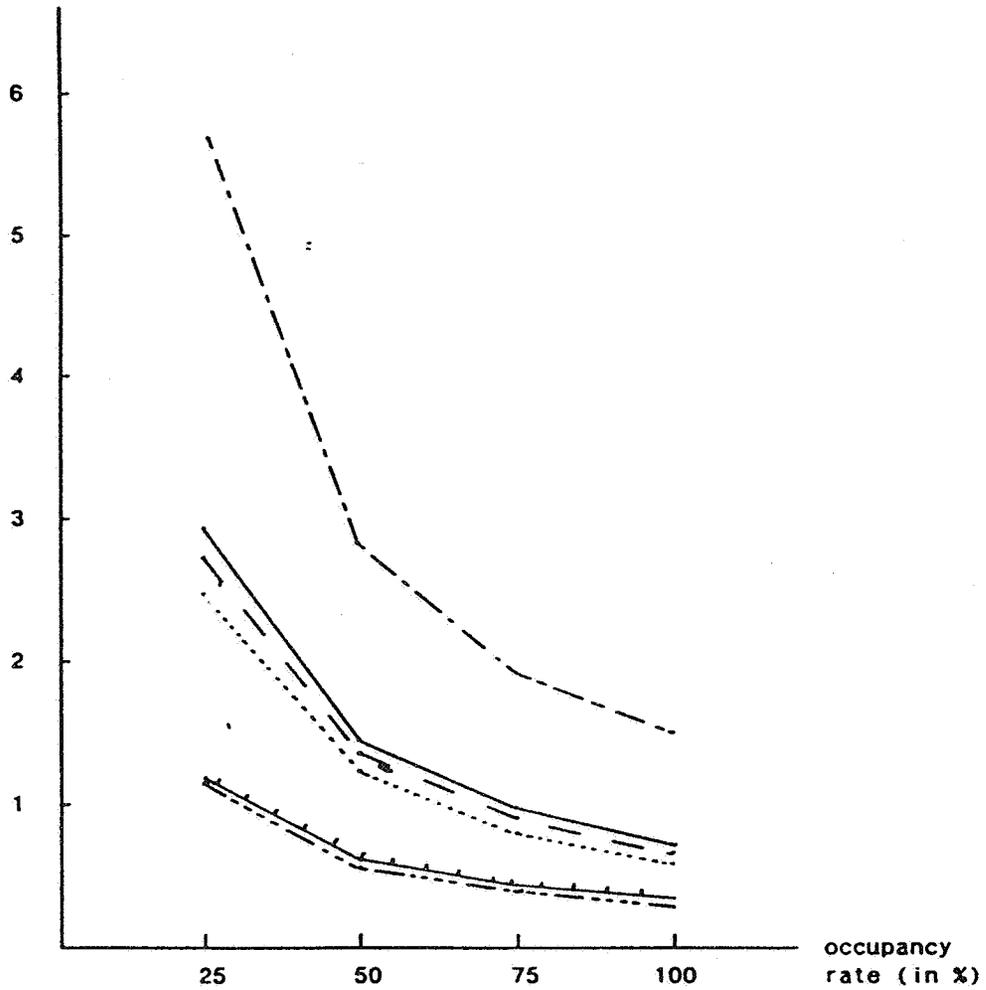


**Figure 2**

**SPECIFIC ENERGY CONSUMPTION OF THE DIFFERENT MEANS OF TRANSPORT AT DIFFERENT OCCUPANCY RATES**

*Passengers*

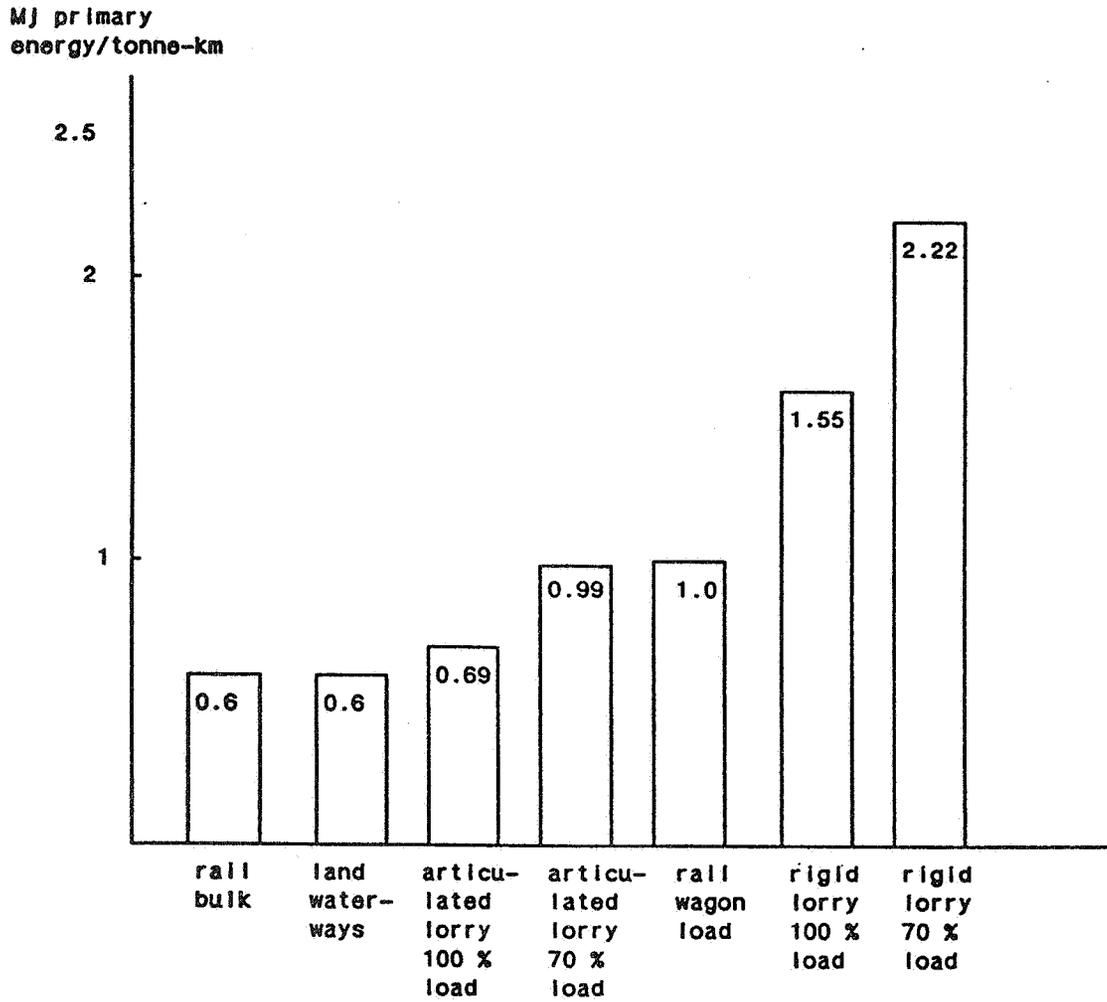
MJ primary  
energy/passenger-km



- |                 |                        |       |
|-----------------|------------------------|-------|
| aircraft        | = Boeing 727           | ----- |
| gasoline car    | = 1.4 - 2.0 cc         | ===== |
| diesel car      | = 1.4 - 2.0 cc         | ----- |
| rail ways       | = intercity            | ----- |
| highspeed train | = London - Paris model | ..... |
| bus             | = bus with 48 seats    | ----- |

**Figure 3** SPECIFIC ENERGY CONSUMPTION OF THE DIFFERENT MEANS OF TRANSPORT

*Freight*



[articulated lorry = 5 axle articulated 38 tons]

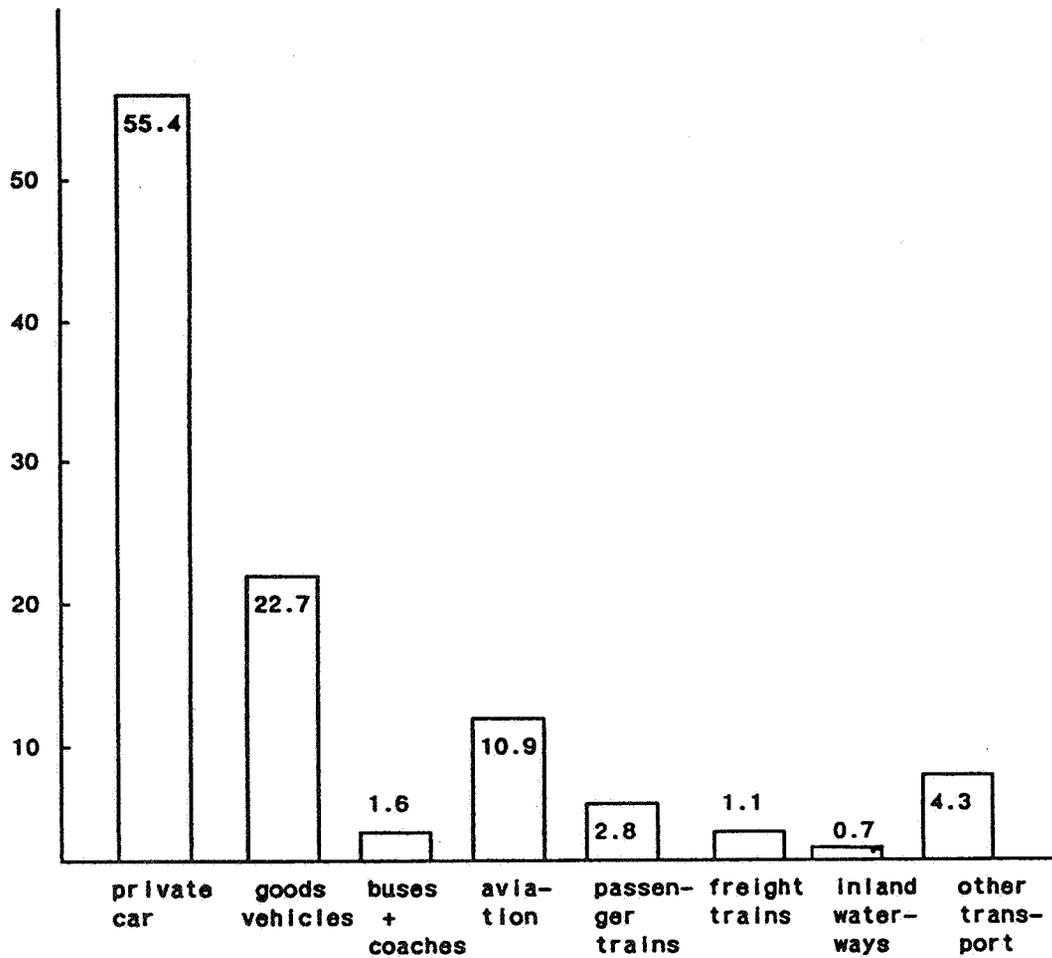
[rigid lorry = 4 axle rigid 20 tons]

**Figure 4**

**CONTRIBUTION OF THE DIFFERENT MEANS OF TRANSPORT TO THE TOTAL CO<sub>2</sub> OUTPUT<sup>(1)</sup> OF THE TRANSPORT SECTOR IN THE COMMUNITY**

*Passengers and Freight*

% of total  
CO<sub>2</sub> output  
of transport sector



(1) CO<sub>2</sub> OUTPUT OF THE TRANSPORT SECTOR IN 1986 = 557 MTONS OR 22.5 % OF TOTAL CO<sub>2</sub> EMISSIONS IN THE COMMUNITY.

Figure 5

FUEL CONSUMPTION OF JET-AIRCRAFT

Ideal Conditions:

- no load
- no waiting before takeoff
- no headwind
- no taxiing after arrival
- optimal flight profile

Least ideal conditions:

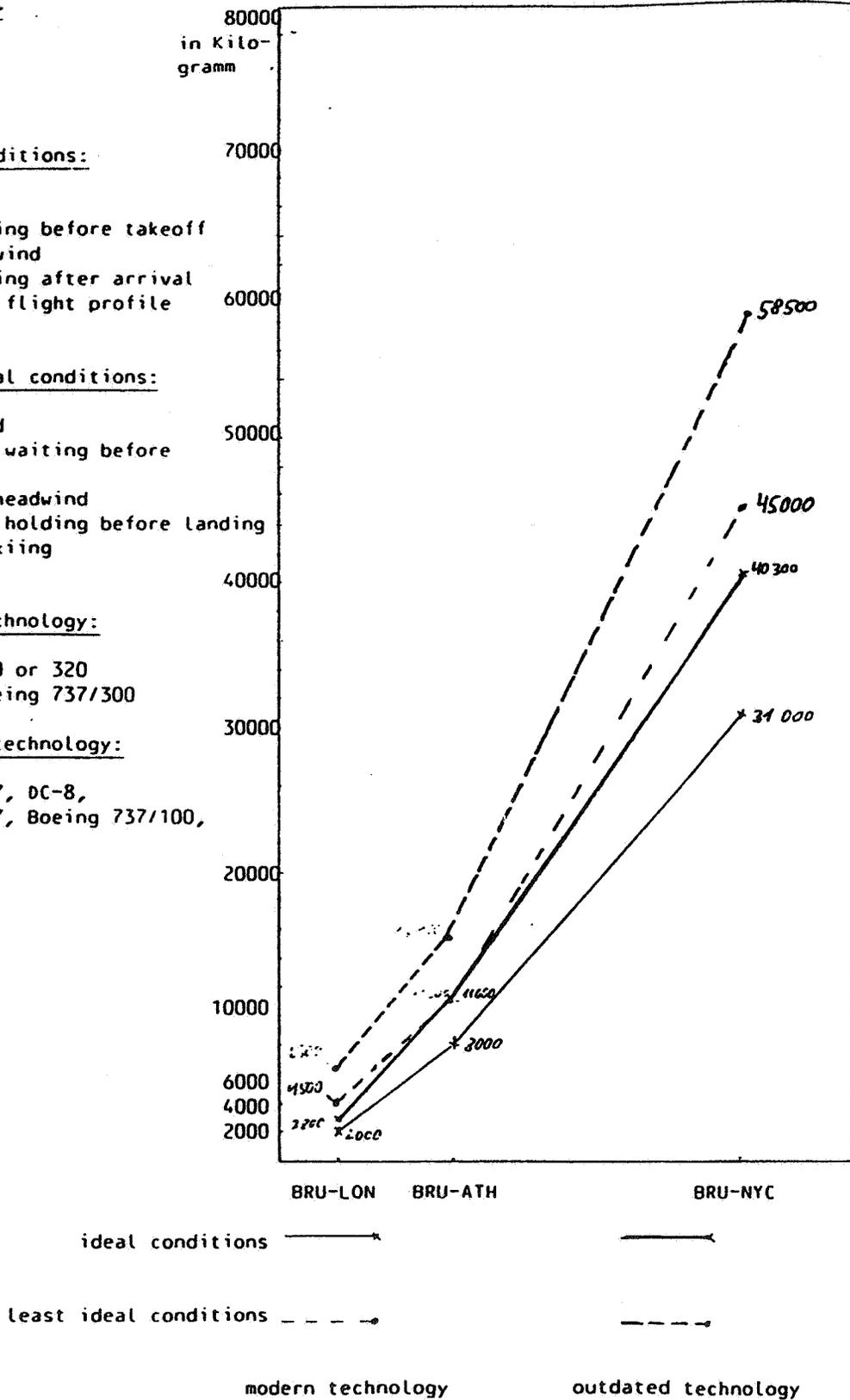
- max. load
- 30 min. waiting before takeoff
- strong headwind
- 30 min. holding before landing
- long taxiing

Modern technology:

Airbus 310 or 320  
MD-80, Boeing 737/300

Outdated technology:

Boeing 707, DC-8,  
Boeing 727, Boeing 737/100,  
DC-9/30

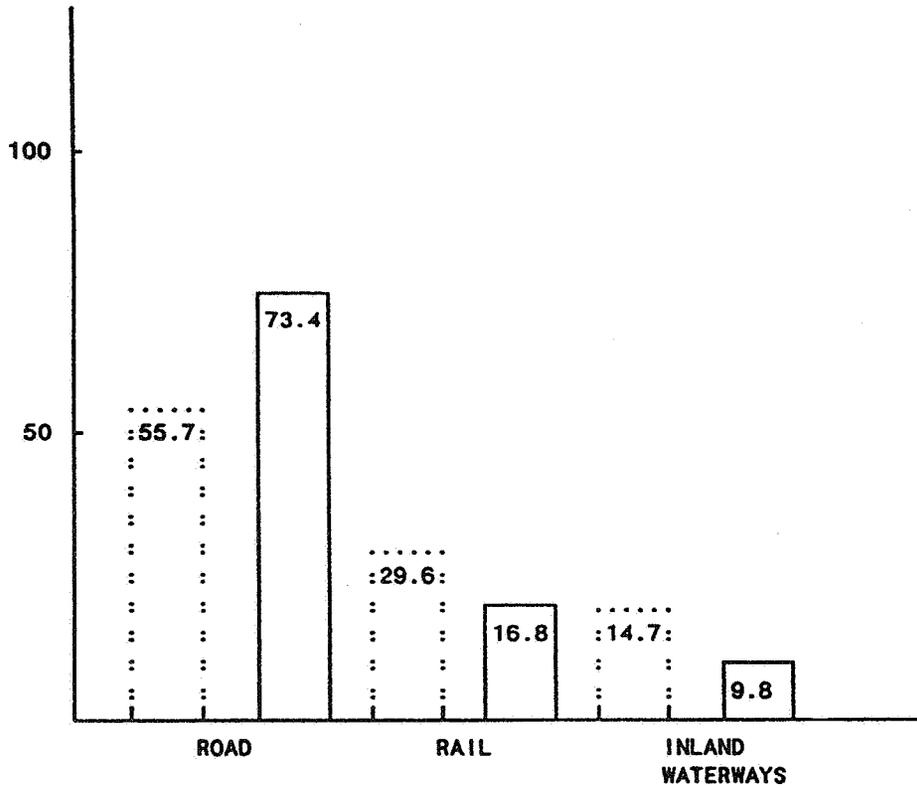


**Figure 6**

**EVOLUTION OF THE MARKET SHARES OF THE DIFFERENT  
INLAND TRANSPORT SECTORS**

*Freight*

Market share  
in %



..... market share in 1970

———— market share in 1988

TABLE 1 :

## PASSENGER TRANSPORT

## PRIMARY ENERGY CONSUMPTION FOR DIFFERENT TRANSPORT MODES

Mode	Total seating capacity per unit	Energy use	
		final energy per 100 km (1)	In MJ primary energy/ vehicle km
1. Gasoline car			
< 1.4	4	7.5 l	2.61
1.4 - 2.0	4	8.6 l	2.98
> 2.0	4	13.4 l	4.65
2. Diesel car			
< 1.4	4	5.9 l	2.26
1.4 - 2.0	4	7.2 l	2.76
> 2.0	4	9.6 l	3.65
3. Railways			
Intercity	563	1,527.7 kwh	160.9
Super sprinter	147	459.6 kwh	48.4
Suburban electrical line	300	749.1 kwh	78.9
High speed train 300 km/h type: Brussels-Paris	375	2,500 kwh	268.65
High speed train 300 km/h type: London-Paris	700	4,150 kwh	437.08
4. Bus/car			
Double decker	100	45.6 l	17.40
Bus	48	36.7 l	14.02
Minibus	20	18.5 l	7.08
Express car	46	29.9 l	11.43
5. Air			
Boeing 727	167	760.7 l	242.82
6. "Soft" transport			
cycling	1		0.06
walking	1		0.16

Source: OECD, Rapport final sur les défaillances du Marché et de l'intervention des pouvoirs publics dans la gestion des transports, Paris, Novembre 1990; and Mens en Ruimte, op.cit..

(1) Conversion coefficients used:

1 MJ primary energy = 0.0287356 l petrol  
0.026178 l diesel  
0.031328 l kerosene  
0.0949487 kwh

**TABLE 2 :****PASSENGER TRANSPORT****SPECIFIC ENERGY CONSUMPTION FOR DIFFERENT TRANSPORT MODES  
AT DIFFERENT OCCUPANCY RATES****(In MJ primary energy/passenger-km)**

MODE	OCCUPANCY RATE			
	25%	50%	75%	100%
<b>1. Gasoline car</b>				
< 1.4	2.61	1.31	0.87	0.62
1.4 - 2.0	2.98	1.49	0.99	0.75
> 2.0	4.65	2.33	1.55	1.16
<b>2. Diesel car</b>				
< 1.4	2.26	1.13	0.75	0.57
1.4 - 2.0	2.76	1.38	0.92	0.69
> 2.0	3.65	1.83	1.22	0.91
<b>3. Railways</b>				
Intercity	1.14	0.57	0.38	0.29
Super sprinter	1.31	0.66	0.44	0.33
Suburban electrical line	1.05	0.59	0.35	0.26
High speed train 300 km/h type: Brussels-Paris	2.86	1.43	0.96	0.72
High speed train 300 km/h type: London-Paris	2.50	1.25	0.83	0.62
<b>4. Bus/car</b>				
Double decker	0.70	0.35	0.23	0.17
Bus	1.17	0.58	0.39	0.29
Minibus	1.42	0.71	0.47	0.35
Express car	0.95	0.50	0.33	0.25
<b>5. Air</b>				
Boeing 727	5.78	2.89	1.94	1.45
<b>6. "Soft" transport</b>				
cycling				0.06
walking				0.16

Source: Computation based on table 1

TABLE 3:

## FREIGHT TRANSPORT

## ENERGY CONSUMPTION FOR DIFFERENT MEANS OF TRANSPORT

Vehicle characteristics	Gross weight tonne	Fuel consumption l/100 km (allowing for part load and empty running)	Specific energy consumption MJ/tonne km		
			50%(2)	70%(2)	100%(2)
<b>1) Road</b>					
5- Axle articulated	38	43.5	1.38	0.99	0.69
4- Axle articulated	32	35.3	1.35	0.96	0.67
3- Axle articulated	20	29.5	1.50	1.07	0.75
4- Axle rigid	20	28.5	3.11	2.22	1.55
3- Axle rigid	16	23.5	1.80	1.28	0.90
Heavy box van	3.5	18.5	8.11	5.80	4.06
Medium van city traffic	1.75	15.5	16.00	11.43	8.00
<b>2) Railways</b>					
Bulk freight traffic	n.a.	n.a.		0.6	
Wagon load traffic (including, collection, delivery to terminals and marshalling)	n.a.	n.a.		1.0	
<b>3) Inland waterways</b>	n.a.	n.a.		0.6	(1)

Source : Dr.M. Waters, Review of TRRL and other Research, U.K. Road Transport Contribution to Greenhouse Gasses, 1990 and for (1), Fondation Roi Baudouin, op. cit..

(2) load factor

**TABLE 4 :**

**EMISSIONS OF VOC, SO<sub>2</sub> AND NO<sub>x</sub> BY ROAD TRANSPORT  
FOR THE YEAR 1985**

CATEGORY	NO <sub>x</sub>	VOC	SO <sub>2</sub>
	( in % of total by road transport)		
. Automobiles & light duty vehicles	55.6	66.9	49.5
. Motorcycles	0.2	9.9	0.8
. Heavy duty vehicles and buses	44.2	8.2	49.5
. Other (deposits of liquid fuels, service stations evaporation)	0.0	15.0(1)	0.2
<b>TOTAL</b>			
In tonne/year	5,592,104	5,328,952	394,776
In % of total emissions by all activities	53.6	27.1	2.9

Source : CORINAIR, 20-11-90

(1) of which evaporation alone accounts for 6,8% of total emissions by road transport

**TABLE 5 :** POLLUTION BY ROAD TRANSPORT ON DIFFERENT ROAD CATEGORIES

Pollutant	GERMANY (cars only) in % on			NETHERLANDS (all vehicles) in % on		
	urban roads	motor ways	Other non-urban	urban roads	motor ways	Other non-urban
CO	43.7	25.9	30.4	53.8	17.9	28.3
NO2	21.7	40.6	37.7	26.3	46.7	27.0
SO2	35.9	28.2	35.9	40.7	n.a.	n.a.
VOC	59.8	15.2	25.0	60.8	14.9	24.3
Particulates	33.8	32.4	33.8	57.5	20.0	22.5

Source : PROGNOs, op. cit.

TABLE 6 :

ENERGY DEMAND AND EMISSION INDICATORS IN  
ROAD TRANSPORT UNDER DIFFERENT DRIVING CIRCUMSTANCES

Type of vehicle	Specific consumption l/100 km	Emission of pollutants (in g/vehicle km)					
		CO	NOx	HC	CO2	SO2	Particulates
- <i>Private car</i>							
Petrol							
urban	11.6	45.0	1.2	6.4	315	-	-
non-urban	5.3	12.5	1.6	1.3	160	-	-
Diesel							
urban	9.4	1.7	0.8	0.5	331	0.08	0.40
non-urban	5.8	0.7	1.7	1.0	201	0.06	0.23
- <i>Bus</i>							
urban	33.0	18.0	15.5	12.0	1158	1.70	n.a.
non-urban	32.0	3.8	15.0	2.7	1123	1.50	n.a.
- <i>Delivery van</i>							
urban	16.0	55.4	3.0	6.0	498	0.18	n.a.
non-urban	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
- <i>Heavy goods vehicle</i>							
urban	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
non-urban	33.0	8.0	17.5	2.8	1158	1.59	n.a.
- <i>Motorcycle</i>							
urban	6.0	15.6	0.1	14.0	163	-	-
non-urban	3.5	8.5	0.2	4.7	106	-	-

Source : DG XVII

**TABLE 7 :****GAS TURBINE AERO-ENGINE EMISSION**

Operation phase	Engine power (%)	Emissions (grams per kilogram of kerosene)		
		CO	HC	NOx
Idle	5	5	20	5
Approach	30	5	2	10
Cruise	60	0	0	20
Take-off	100	0	0	40

Source : Air-Line Business, The Magazine for Airline Management , October 1990, p. 27.

TABLE 8:

## EVOLUTION OF TRANSPORT IN THE COMMUNITY

1970-1988

	Transport in bill. tonne-km or pass-km		Yearly growth in %	Market share in tonne-km or pass-km	
	1970	1988		1970	1988
<b>1. INLAND</b>					
<i>Freight</i>					
. Road	389.1	772.6	3.9	55.7	73.4
. Inland waterways	103.1	103.2	0	14.7	9.8
. Rail	207.0	176.6	-0.9	29.6	16.8
<b>Total</b>	<b>699.2</b>	<b>1,052.4</b>	<b>2.3</b>	<b>100.0</b>	<b>100.0</b>
<i>Passengers</i>					
. Road: private car/bus	1,590.6	2,826.3	3.2	89.7	92.5
. Rail	181.1	229.7	1.3	10.3	7.5
<b>Total</b>	<b>1,772.9</b>	<b>3,055.7</b>	<b>3.1</b>	<b>100.0</b>	<b>100.0</b>
<b>2. AIR</b>					
<i>Freight</i>	-	-	-	-	-
<i>Passengers</i>	117.9	284.8(1)	4.7(2)	-	-
<b>3. MARITIME</b>					
<i>Freight</i>	85(3)	100(4)	1.2(5)	-	-
<i>Passengers</i>	-	-	-	-	-

Source: CEMT, Consultants.

(1) Figure for the year 1985

(2) Figure for the period 1970-1985

(3) Figure for the year 1975

(4) Figure for the year 1989

(5) Figure for the period 1975-1989

**TABLE 9: EVOLUTION OF ROAD VEHICLES AND ROAD TRAFFIC IN THE COMMUNITY  
1970-1987**

	1970	1987	Yearly growth 1970-1987 in %
- Passenger cars in use (in thousand)	57,459	116,947	4.3
- Goods vehicles in use (in thousand)	7,419	12,881	3.3
- Vehicle-km passenger cars (in billion)	760.5	1,399	3.7
- Vehicle-km goods vehicles (in billion)	157.6	275.4	3.3

Source: OECD, Environmental data, compendium 1989.

**TABLE 10 : FORECASTS FOR THE TRANSPORT SECTOR IN THE COMMUNITY  
UP TO 1995**

	1995 (In billion) tonne-km or passenger-km	Forecast yearly growth 1989-1995 in %
<b>1. <u>INLAND</u></b>		
<i>Freight</i>		
. Road	1,002	3.8
. Inland waterways	n.a.	n.a.
. Rail	210	2.2
<b>Total</b>	n.a.	n.a.
<i>Passengers</i>		
. Road	3,712	2.9
. Rail	295	3.3
<b>Total</b>	4,007	2.9
<b>2. <u>AIR</u></b>		
<i>Freight</i>	20.5	5.5
<i>Passengers</i>	453.4	5.2
<b>3. <u>MARITIME</u></b>		
<i>Freight</i>	n.a.	n.a.
<i>Passengers</i>	n.a.	n.a.

Source: Europe in 1995, Economic outlook by sector, April 1991.