

# COMMISSION OF THE EUROPEAN COMMUNITIES

COM(75) 493 final

Brussels, 3 October 1975

Commission's Interim Report to the  
Council of Ministers on Charging for the  
Use of Transport Infrastructures

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COM(75) 493 final

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Summary

1. In 1971 the Commission proposed the implementation of Infrastructure Charging as a major step towards a Common Transport Policy. The object was to identify all the costs arising from the use of road, rail and inland waterway infrastructures, to find out precisely who caused these costs and subsequently to recover the costs from the users responsible. Identification would clarify the cost of taking decisions in transport. Cost allocation and charging would lead to better use of existing infrastructures and help to equalize competitive conditions in the industry.
  
2. The Commission therefore submitted to the Council a proposal for introducing a Common System of Charging for the Use of Transport Infrastructures. Before adopting this proposal, the Council called for detailed studies of the potential impact of Infrastructure Charging on rail, road and inland waterway transport. In parallel with these studies, work was also carried out on the special problems of urban infrastructures, on the taxation of commercial road vehicles and on the reporting of data relating to expenditure on and the use of infrastructures.
  
3. This Interim Report shows the substantial progress made since 1971, even if not all the studies have been completed. A further paper to analyse outstanding problems and indicate possible future lines of action will follow.
  
4. The studies naturally concentrated on the most urgent and important questions. Since Member States were primarily interested in goods transport by road, much more work was done on roads than on railways or waterways, whilst interurban freight movements were given priority over passenger traffic

and special urban problems. Considerable progress was made in identifying the various costs, but rather less is known on how they may be allocated and subsequently charged to users.

5. The Report thus shows in which directions it will be possible to advance fairly quickly. It also makes it clear where important problems remain which may call for new approaches of aim and method. One thing stands out clearly : the interest shown in Infrastructure Charging by governments and others in the world of transport indicates the importance of the subject and the urgent need to make further progress.

Part I

Introduction and basis of report

A. Background

6. One of the important elements in the Common Transport Policy is the concept of Infrastructure Charging. This envisages first of all identifying all the costs arising from the use of transport infrastructures and then finding out precisely who caused them.. The subsequent step is to recover these costs from the users of road, rail and inland waterways.

7. The aims of Infrastructure Charging relate to the above steps:

- identifying or making infrastructure costs transparent mainly helps to clarify the effect of taking decisions in transport;
- allocating and charging costs help to achieve better use of existing infrastructures and to equalize competitive conditions in the industry.

8. Accordingly in March 1971, the Commission submitted a proposal for a Council Decision on the introduction of a Common System of Charging for the Use of Infrastructures, accompanied by a Memorandum (1) providing detailed background. In December 1971 the Council requested Member States (2) to carry out and the Commission to coordinate detailed studies on the impact of these proposals on road, rail and inland waterway transport. The Council also asked the Committee of Permanent Representatives to examine specific related problems.

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(1) O.J. No. C 62, 22 June 1971

(2) Doc. R/38/72 (TRANS 1) 13 January 1972.

9. Concurrently, work was pursued on the proposed first Council Directive on the Adjustment of National Taxation Systems for Commercial Road Vehicles (1) submitted in July 1968 and on EEC Regulation 1108/70 (2) which provides a reporting system for Expenditure on and the Use of Transport Infrastructures, whilst in January 1970 the Council decided on special studies on Urban Infrastructure problems (3).

B. Work programme requested by the Council

10. As indicated in point 8 above the Council requested that as part of the general Infrastructure Charging work, the following questions relating to the three modes of transport should be studied by Member States together with the Commission :

- a) the marginal cost of use;
- b) other marginal social costs: congestion, noise, air pollution and accidents;
- c) budgetary equilibrium charges;
- d) total expenditure to be covered by transport users.

11. In addition to the four main study areas above, the Council requested that eight specific points should be examined by the Committee of Permanent Representatives :

- a) the connexion between Infrastructure Charging and the selection of investments;
- b) the legal basis for Infrastructure Charging on International Waterways;
- c) the averaging of charges;
- d) methods of charging in the road sector;

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(1) Doc. (68)651 final and O.J. C 95, 21 September 1968  
 (2) O.J. No. L 130, 15 June 1970  
 (3) O.J. No. L 23, 30 January 1970.

- e) arrangements concerning private cars;
- f) the relationship between excise taxes on petrol and those on gasoil;
- g) institutional provisions;
- h) temporary arrangements for railways.

C. Purpose of the report

12. The purpose of this Report is to meet the Council's request to be informed of the progress made and the results of the many studies in hand. Whilst the Report may be read on its own, a number of Appendices are provided for those wishing to go into more detail.

13. Much progress has been made since 1971, but the pace has been slower than hoped for. Planned originally for completion in 1973, studies have been delayed partly because of the enlargement of the Community and the consequential reorganization of the Commission's Departments and partly for sheer lack of national data. Moreover, new problems which arose during the studies caused some changes of direction in this complex field. In order to avoid the further delay which would have resulted from an attempt to complete all the studies the Council agreed that an Interim Report should be presented.

14. The major questions treated in this Report have been studied by working groups and outside experts to different degrees of depth and detail. Moreover some of them form part of separate proposals for Community action. It has therefore been considered useful to report results directly under each heading as well as to group various elements under the more general concepts of the Infrastructure Charging System, the Taxation of Commercial Road Vehicles and Urban Studies.

15. In addition, at the request of the Committee of Permanent Representatives, the Commission furnished specific contributions on three of the detailed items entrusted to the former; the Commission's views on the remaining five points were held to be adequately covered by its 1971 Memorandum already referred to.



PART II

Report on infrastructure charging studies

A. Infrastructure charging: the general system

Basis and aims

16. Infrastructure charging is based on the idea that the full costs which arise from the use of transport infrastructure should be identified, allocated to and borne by its users. Its major aims are to assist decision taking by making costs clear and transparent, to improve the use of existing infrastructures, to harmonise conditions of competition in transport, and to provide financial resources to cover both operating and investment costs.

17. The intention is that all the costs attributable to a mode of transport, and within that mode to each category of users, should be identified, allocated and paid for. In principle, revenue from the charges should be used to meet these costs and in particular to operate and improve infrastructures.

The system

18. The draft Council Decision, which was amended in August 1974 following advice from the European Parliament and the Economic and Social Committee, may be found in the Appendices (No. I). In brief, the system envisages that transport users should pay:

- a) the marginal social costs caused by the use of infrastructures;
- b) a budgetary equilibrium charge designed to cover any deficit between total expenditure and revenue derived from charging marginal social costs.

19. As defined here, marginal social costs are those attributable to an incremental unit of traffic and fall into two main categories :

- a) the marginal cost of use, i.e. the increase in the expenditure imposed on the owner of the infrastructure by the extra traffic;
- b) other (or external) marginal costs, i.e. the increase in the costs external to the existence of the infrastructure, but arising from its use and subdivided into :
  - (i) the marginal cost of congestion, i.e. the increase in costs imposed on the rest of the traffic by the extra traffic;
  - (ii) other marginal external costs, i.e. the increase in all other costs such as those of noise, air pollution and accidents caused to society by the extra traffic.

20. Expenditures to be covered include :

- a) operating, maintenance and general expenses for infrastructures;
- b) infrastructure investments, made up of direct expenses where loan funds are not used as well as the interest on and amortization of any loan fund taken up;
- c) expenses to meet congestion and other external costs.

The expenditure should relate only to the transport function of the infrastructure concerned.

21. In achieving budgetary equilibrium problems arise both of time and place. To solve the difficulties related to time, a period of several years should be used to determine and therefore average out costs, traffic volumes and charges to the users. The spatial problems concern the geographical or physical extent of the infrastructure network required to balance its budget; they are a matter of cross-subsidization within each mode. A balanced

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approach is recommended here because high infrastructure charges for a specific network might unnecessarily discourage demand whilst charges averaged out over a large area would not be an effective tool for appraising investment proposals.

#### Impact on transport

22. Since the current situation and the operating characteristics of the three modes of inland transport are not the same, the repercussions of Infrastructure Charging on them will differ. A long period of adaptation to the full system as well as special treatment of particular problems are therefore necessary.

23. For example the railways are at least in principle responsible for all their infrastructure costs. Accordingly, where they compete with roads or waterways, allowance should be made for the degree to which each of these competing means of transport actually cover its infrastructure costs.

24. For waterways, substantial physical differences between networks may call for more detailed investigation; moreover in this field there is a wide gap between costs and the revenue contributed by users.

25. Problems in the road sector are both more complex and more urgent than for rail and waterways. The following two sections deal with work done on the taxation of commercial road vehicles and the special problems of urban areas.

#### B. The taxation of commercial road vehicles

26. For many years priority in the field of Infrastructure Charging has been given to commercial road vehicles. Following a 1964 proposal to eliminate double taxation, a draft first Council Directive, providing for the Adjustment of National Taxation Systems for such vehicles, was submitted in 1968 (1). Much detailed work has been carried out in this field, right up to

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(1) O.J. No. C 95 of 21 September 1968

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the April 1975 report (1). At its meeting in December 1974 the Council stated its intention to discuss and, if possible, to adopt the Directive at its next meeting; the text currently being examined by the Council's Transport Group may be found in the minutes of their meetings (2).

27. The basic principles of this first Directive are that the specific taxes paid by a commercial road vehicle should :

- a) take into account and at least cover its marginal cost of use;
- b) be made up of the excise tax on gasoil and a vehicle tax, the latter being calculated in accordance with common methods throughout the Community.

28. In devising such a system many technical, economic and fiscal aspects were examined, including :

- a) methods for calculating marginal costs of use (see paras 39-44);
- b) the calculation of excise taxes on gasoil;
- c) the field of application (e.g. extent of road network, lower limit of vehicle tonnage, exemptions);
- d) taxation practices (e.g. lorries and trailers separately or together);
- e) adaptability of the system to changes in costs, fuel taxes etc.;
- f) the problems of the "supplement" to be added to marginal costs of use to ensure the required level of revenue from taxes on vehicles and fuel.

29. Faced with these many problems, greater scope is being provided for specific national difficulties to be overcome, whilst retaining the basic principles of the proposed Directive. For example cost calculation methods are being handled more flexibly to overcome problems due to lack of data and differences in national accounting systems. Member States will be free to

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(1) Doc. SEC(75)1310 of 7 April 1975

(2) Doc. R/1429/75 (TRANS 45) of 4 June 1975

tax drawing vehicles and trailers separately or as a combination, whilst optional adjustments to the Community system will allow better alignment with taxes on vehicles not covered by the Directive. Finally, it is important to stress that in this first proposal no attempt is being made to harmonize tax rates.

30. As regards international transport, the Directive proposes that vehicle taxes should be paid only in the Member State of registration even if the vehicle travels on roads of other Member States; this is known as the principle of "nationality" rather than of "territoriality".

31. The draft Directive constitutes only a first step towards harmonization of vehicle taxes and further possible developments are to be considered, such as :

- harmonizing tax rates for international goods vehicle traffic;
- harmonizing excise taxes on fuels;
- basing the system on real rather than on nominal axle loads;
- improving cost calculation methods.

Such further developments should bear in mind the need for users, transport firms, vehicle manufacturers and the authorities to be given time to assess and assimilate the effects of any new system.

C. Urban studies

32. The Commission's Pilot Study on Infrastructure Charging (1), considered that the special problems of determining urban infrastructure costs and their allocation to users should be examined separately. An "Urban Studies" groups

(1) Doc. SEC(69) 700 final of 12 March 1969

was therefore set up and in January 1970 the Council approved the initiation of studies of methods for calculating and charging all the marginal social costs referred to in para 19.

33. To start with, data were collected on four large and one medium-sized European cities (Amsterdam, Brussels, Cologne, Lyons and Verona) showing the infrastructure network, traffic characteristics, parking facilities, public transport etc. With such data in hand, the important phenomenon of congestion was studied by means of traffic speed-flow analyses in these cities and valuable information obtained on the complexities of traffic flow, especially in central urban areas. Coupled with investigations into the value of users' time, these studies all helped to deal with the determination of congestion costs, as reported in paras 46 - 51. In addition some Member States carried out special studies: Germany on the cost of environmental pollution and Belgium on practical charging systems.

34. The costs of environmental pollution caused by traffic noise and vehicle emissions were studied in a multi-disciplinary report sponsored by the Commission and carried out by the Verein Deutscher Ingenieure (V.D.I.). The conclusions of this comprehensive 1100 page document are briefly summarized in paras 52 -54 but since time has so far permitted only a cursory examination much more work will have to be done in this potentially significant field, where costs at least in urban areas might be of the same order of magnitude as vehicle fuel costs.

35. Still in the field of cost determination, it was concluded that methods for calculating the marginal costs of use of non-urban roads could be applied in towns. Consideration of the marginal cost of accidents was deferred, since the method set out in the Pilot Study could be used meanwhile.

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36. A study of practical systems of charging for the use of urban roads was carried out by the Société Belge D'Economie et de Mathématique Appliquées (SOBEMAP), taking Brussels as an example. It was concluded that the system most likely to succeed had to be

- acceptable legally and administratively;
- understandable to users,
- reasonably equitable, and
- effective in reducing congestion without transferring it elsewhere.

A simple form of supplementary licensing was thought on balance to be the system most likely to fulfil these requirements.

37. In conclusion it may be said that the major elements involved in urban congestion costs have been studied. Feasible methods have been developed for calculating congestion costs, but they cannot yet be used as a basis for urban road charging systems. Further discussion and studies are needed to develop these economic measures and integrate them into the total context of urban transport planning.

#### D. The determination of marginal social costs

38. As indicated in earlier chapters, marginal (social) costs fall into two main categories :

- a) the cost of use, i.e. essentially wear and tear
- b) other (external) costs : congestion, noise, air pollution and accidents.

The Commission's Working Groups analysed these costs separately for the three modes of transport and as part of the overall studies referred to in Chapter II A - C.

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Marginal cost of use - roads

39. During the preparation of the draft Directive on the taxation of commercial road vehicles, the Working Group concerned drew up an Annex (1), most of which deals with methods for calculating the marginal (social) cost of use. This increase in the cost of operating, administering, maintaining and renewing road infrastructures caused by an additional traffic unit includes traffic police costs as well as "wear and tear".

40. Road maintenance and renewal operations are divided into fixed costs and those which tend to vary with traffic levels; the latter are allocated to commercial vehicles according to three criteria : vehicles-km, nominal axle weights and nominal axle weights to the fourth power. In each variable cost category the marginalisable proportion is ascertained by one of three methods which provide statistical comparisons of cost and traffic levels over time or in space, or which analyse the relation of costs to traffic in a qualitative manner. For each of the three criteria mentioned it is proposed to fix a minimum marginalisable proportion. Taking into account the approximate character of the underlying data, the procedure allows a marginal (social) cost of use to be allocated to each type of vehicle with reasonable accuracy. Where cost data are not available as such, expenditures are used as a basis.

41. Upon the request of the Council the Member States undertook without encountering major difficulties, a "test" calculation of the marginal costs of use for 1971 on the basis of the methods described in the Annex. The Commission's Departments drew up a report (2) reproducing the calculations of eight Member States and comparing their results.

Marginal cost of use - railways

42. The Working Group concerned produced a draft paper (3) dealing with methods for calculating the marginal (social) costs of use of railway

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(1) Doc. R/2750/74 (TRANS 174)

(2) Doc. SEC(75) 1310

(3) Doc. C/TL/C/TL/05-2/74



infrastructures along the lines of the one worked out for roads. Costs are to be allocated according to whether they vary in relation to gross ton-km worked, train-km and the number of trains; electric power output and copper consumption may also be relevant. As for roads, minimum rates of marginalisation may have to be determined for these categories.

43. Initial calculations by Member States of these costs for 1971 seem to show lower marginalisation rates than those for roads, but detailed analysis is still under way.

#### Marginal cost of use - inland waterways

44. The Working Group concerned has prepared a draft paper (1) on calculating methods along the lines proposed for the other modes of transport. Costs are to be allocated according to whether they vary in relation to vessel-km, deadweight ton-km, the number of lock cycles or the number of vessels passing through locks.

45. The first calculations carried out, particularly by France and Germany, have highlighted the practical problems resulting from the very detailed breakdown of both the networks and the expenses. These problems, and such matters as equivalence coefficients for vessel categories and calculations for other Member States, will require further examination.

#### Marginal cost of congestion

46. Recent work on congestion costs has concentrated on urban roads, where congestion plays a particularly important role. Rail congestion was discussed in the Pilot Study, which also considered that methods suggested for road congestion costs could apply to inland waterways.

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(1) Doc. CTE/GT3/04-2/74

47. Three elements may be distinguished in congestion costs :

- time lost by road users;
- increased fuel consumption and vehicle maintenance;
- the immobilisation of freight.

48. Time lost by road users was considered by the Urban Studies Group to be the most important element, requiring priority attention. To evaluate it both its amount and its value have to be determined. The amount of time lost may be derived from the relationship of traffic speed to flow, or traffic density to flow. Care must be taken to distinguish between relatively stable conditions and unstable situations which may occur when traffic saturation is reached.

49. In order to deal with both situations, four methods were identified as acceptable approaches to quantifying the time lost by users, with the choice depending on the particular problems and technical preferences of the individual urban authorities. More detailed descriptions of these methods are included in Appendix II.

50. The valuation of the time of transport users in monetary terms was studied both nationally and at international level via the ECMT Round Table Conferences. Despite remaining problems progress was made towards developing a simple methodology which would distinguish working and non-working time, and would value these time categories as a percentage of gross or net income.

51. Increases in vehicle costs were rated second in importance to time lost by transport users and they should give rise to fewer problems of calculation methods. The immobilisation of freight was held by the Pilot Study to be a minor factor. Both elements may therefore be considered at a later stage.

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Marginal cost of noise

52. Road traffic is recognised as the primary source of environmental noise in virtually all Member States. The VDI research team referred to in Chapter III. C attempted to evaluate the cost of the effects of noise, but concluded that this could not be done directly. As the summary of their report in Appendix III shows, they adopted an indirect approach by calculating the costs of both active and passive noise prevention or elimination measures. Active prevention reduced the noise level at emission source by e.g. improved vehicle silencing; passive prevention protects those affected by traffic noise by providing sound insulated windows, screen walls, improved street surfaces, tunnels etc. Cost estimates related to conditions in Germany were provided.

Marginal cost of air pollution

53. Urban air pollution caused by vehicle emissions is determined by traffic-related characteristics such as density and driving conditions (stop-go or smooth flow) and by vehicle-related characteristics such as engine type and size.

54. As in the case of traffic noise the VDI experts adopted an indirect approach by estimating the cost of measures to prevent or eliminate harmful effects. Appendix III shows that reductions of 40% in present emission levels of carbon monoxide, and of 30% for nitrogen oxides, were envisaged as being in line with current thinking about petrol engine exhaust standards. Again, the experts estimated potential marginal costs applicable to German conditions.

Marginal cost of accidents

55. For the purpose of Infrastructure Charging it would appear that the cost of accidents is important only for roads and may be disregarded when

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considering railways and inland waterways. The evaluation of road accidents costs has been the subject of many studies and was also examined in the Pilot Study which provided detailed procedures for calculating the marginal costs of accidents, taking insurance into account.

E. Budgetary equilibrium charges

56. There is almost invariably a financial deficit between total expenditure on transport infrastructure and the revenue derived from charging marginal social costs. Such a deficit should be recovered from the users in the form of budgetary equilibrium charges.

57. The problems of devising appropriate methods for attributing these equilibrium charges to users were originally investigated by Professor C.J. OORT and subsequently revised by Drs. MAASKANT in a comprehensive report finally completed in June 1975. This report which relies extensively on the "ALLAIS Report" (1) and the Pilot Study examines in considerable depth the theory of welfare economics which leads to marginal social cost pricing and the optimum allocation of resources in the whole economy. Based on this examination five alternative methods of setting equilibrium charges are identified and their merits are evaluated both in theory and as regards practical applicability to transport infrastructures.

58. The method finally recommended is that equilibrium charges should be equal or proportional to marginal social costs which would prevail at a lower (hypothetical optimum) level of infrastructure capacity. The rationale behind this proposal is that when the capacity of the infrastructure is larger than is necessary for the actual level of use, a deficit will arise because the revenue from optimum pricing at marginal social cost will not cover total costs. The users therefore benefit from this larger capacity

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(1) Options in Transport Tariff Policy. Studies : Transport Series No. 1, Brussels 1965.

by not paying the higher marginal social costs which would prevail at the lower level of capacity.

Ways and means of applying the proposed method to the various modes and infrastructures are reviewed and the possible effects assessed.

59. It is emphasized that the OORT report has not yet been analysed in depth by either the Commission's Departments or by government experts.

F. Reporting on infrastructure expenditure and use

60. To provide a statistical and accounting basis for an Infrastructure Charging system, data on infrastructure expenses and use are needed. These are reported annually by Member States for the three modes of transport in accordance with Regulation 1108/70 (1).

61. Expenses are divided into investment, operations, police (except for railways) and overheads, whilst traffic data are provided in - vehicle-km and axle-km for roads; - train-km and gross ton-km worked for railways, and - vessel-km, deadweight ton-km and number of vessels passing locks for inland waterways.

62. So far, reports dealing with the years 1971 (2) and 1972 (3) have been issued; they include data which the three new Member States reported unofficially in advance of 1974 when the above Regulation began to apply to

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(1) O.J. L 130, 15 June 1970

(2) Doc. SEC(74) 5285 final

(3) COM(75) 312 final

to them. It is intended to submit the report for the year 1973 to the Council towards the end of 1975.

63. The experts concerned have begun to discuss problems encountered in applying this Regulation as well as possible measures to bring it more into line with current Infrastructure Charging developments. The main points are :

- a) identifying the transport share of total infrastructure expenditure;
- b) breaking down investment expenses into new construction and extensions on the one hand, and reconstruction and renewal on the other hand;
- c) analysing expenses in accordance with the criteria currently used for variation (see para 40);
- d) laying down criteria for differentiating urban and non-urban roads;
- e) reducing the frequency of reporting certain data;
- f) methods for ascertaining real axle loads.

#### G. Miscellaneous

##### The selection of investments

64. A study was carried out during 1974 by Professors K.M. GWILLIAM and J.A. ZIGHERA on the interdependence between a system of infrastructure charging, based on pricing at marginal social cost with budgetary equilibrium, and decision making in infrastructure investments. A brief summary of the study may be found in Appendix IV.

65. In analysing the relevant economic theory the authors expressed some criticism of the validity of budgetary equilibrium but did not suggest any practical alternative. They held that in principle Infrastructure Charging, by setting values on external, non-quantifiable effects such as noise, air

pollution and accidents, had an important bearing on investment decision making. In interurban situations, cost-benefit analysis techniques could adequately deal with the mainly tangible factors involved and the project rate of return should not depend greatly on the pricing policy adopted.

66. In urban areas, however, congestion and many factors outside transport played a more important role. Simple financial target setting was therefore less likely to result in an overall optimum and priority should be given to achieving what was considered to be the "right" traffic pattern on overall planning grounds.

67. As a broad conclusion the authors felt that current Community approaches to Infrastructure Charging were compatible with investment selection provided their connexion was recognized; the separate development of each should not be delayed because of this interaction.

Professors Gwilliam and Zighera also underlined the problems which may arise in underdeveloped regions regarding the financing of "stimulating" investments which will not pay their way during the early years if the system is applied without flexibility. These problems should be analyzed and solved before a definite system is adopted.

#### International waterways

68. The question relating to the legal basis for Infrastructure Charging on international waterways is one of determining whether the 1868 Act of Mannheim, which exempts Rhine shipping from all charges "based solely on the act of shipping", is compatible with infrastructure charges.

69. Firstly it needs to be stated that according to the jurisprudence of the Court of Justice article 234 of the Treaty does not permit the Member States to invoke between them the rights and obligations of previous agreements in order to evade obligations due to the Treaty; it restricts

itself to guaranteeing obligations of previous agreements with third countries. As a result there are no juridical hindrances to the application of the charging system for infrastructures except to undertakings established in a third country which claims for its nationals the rights under the Mannheim Act. It follows that the problem primarily concerns relations with Switzerland.

Though it is difficult to express a final view without the charging system being definitive the general opinion of the Commission is that payments for the use of infrastructures are compatible with the Act of Mannheim. The exemption granted in this Act is not aimed at charges for a service rendered which is fully justified by the need to recover expenditure on improvements to the Rhine. It will no doubt be necessary to discuss these problems with Switzerland when a more advanced stage has been reached in the development of the charging system.

#### The averaging of charges

70. The extent to which infrastructure charges should be averaged over networks is connected with the problems relating to the determination of equilibrium charges. These, it will be remembered, should furnish the additional revenue required to cover operating and investment expenses where charging at the level of marginal social costs does not allow the budget to be balanced. It is a matter of cross-subsidisation within each mode of transport, defined in terms of the system or the geographical area for which budgetary equilibrium must be attained.

71. If charges were calculated for a particular infrastructure or a small network, the users concerned would bear the total financial outlay for building and operating that infrastructure. Such a system of charges would help to select amongst alternative investment proposals, but it would carry the risk of leading to levels of charges much higher than marginal social costs and therefore of discouraging demand.

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On the other hand, averaging out or equalizing charges over a wide area would not allow specific investment to be influenced. At the same time, however, it would not hinder optimum use of existing capacity.

72. The need is to arrive at a balanced solution for this problems which applies particularly to inland waterways, and in which possible regional implications should not be forgotten. A Commission document (1) dealing with this subject reproduced in an appendix some of the ideas of the authors of the "ALLAIS Report".

(1) Doc. SEC(72) 2822

Part III

Conclusion

73. This Interim Report shows that substantial but uneven progress has been made in the complex field of Infrastructure Charging. For instance, as far as the determination of marginal social costs is concerned, much more is known about the marginal cost of using roads, particularly for commercial vehicles operating out of town, than for rail or inland waterways. A good beginning has been made in dealing with congestion costs, enough is known about noise and air pollution to encourage further analysis of available information, and the cost of accidents may be tackled with some confidence.

74. A good start has been made on assembling and exploiting the basic national data relating to expenditure on and the use of infrastructures; these now need to be adapted to the need of a modern Infrastructure Charging system.

75. In the field of allocating and charging cost to users much work remains to be done, including both the rationale and the methods. Nevertheless progress on commercial road vehicles has shown the way, and as a start for future work, available research material on such aspects as budgetary equilibrium charges will need to be processed and put to use.

76. Such results show in which directions it should be possible to advance fairly quickly and where, on the contrary, serious difficulties remain which may call for new approaches both as to aims and methods. These will be the subject of a second paper which will analyse outstanding problems in the light of developments since the original proposals on Infrastructure Charging were submitted. It is also intended to indicate in that paper possible priorities and lines of action to deal with present and possible future problems.

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77. In the light of what has been said there is no doubt that the subject of Infrastructure Charging continues to arouse the greatest possible interest both in government and the world of transport. Such indications of its importance both intrinsically and in relation to other elements of the Community's transport policy are convincing evidence of the need to make further urgent progress.

Annex I

Draft Council Decision on Infrastructure Charging

## EXPLANATORY MEMORANDUM

In the agreement of 22 June 1965 on the organization of the transport market the Council included among measures for approximating the conditions governing the operation of the various markets the adoption of a common solution to the problems of charging for the use of transport infrastructure. In order to attain this objective the Commission presented to the Council on 29 March 1971 a proposal for a decision on the introduction of a common system of charging for the use of transport infrastructure<sup>1</sup>.

This decision defines the general principles of the system chosen, which is based on charging for the marginal social cost while at the same time requiring revenue to cover expenditure; only by this method is it possible to ensure the best use of infrastructures and at the same time to obtain sufficient revenue to finance all the expenditure incurred by the creation and operation of these infrastructures. In this way a foundation will be created for later measures designed to implement the policy chosen for the three modes of transport, the content and structure of which are set out in the memorandum from the Commission to the Council on charging for the use of infrastructure.

The European Parliament expressed its Opinion on this proposal at its meeting on 16 November 1973<sup>2</sup>, and the Economic and Social Committee on 28 September 1972<sup>3</sup>.

After examining carefully the comments made in these Opinions, the Commission has decided to act upon some of them and for this purpose to amend, in accordance with Article 149, paragraph 2 of the Treaty, the initial proposal for a decision.

<sup>1</sup>OJ No C 62, 22 June 1971, p. 15.

<sup>2</sup>OJ No C 108, 10 December 1973, p. 67.

<sup>3</sup>OJ No C 123, 27 November 1972, p. 11.

These amendments relate mainly to the following matters:

Recital 1

The limitation of the proposed measure to railway, road and inland navigation infrastructures has been considered advisable having regard to the fact that the Council has not yet decided on the basis of Article 84(2) to apply the rules of a common transport policy to sea and air traffic. The European Parliament desires, however, the introduction of a Recital 1(a) laying down that the structure of the system of charges must be devised with a view to its later application to other forms of transport, so that their inclusion therein will not necessitate any major amendments.

Recital 3

The European Parliament proposes that to the notion of "best use of existing infrastructures", which in its Opinion is too concise, there be added a supplementary notion, namely, the promotion of a distribution of transport between the various means and infrastructures which will be advantageous to the economy as a whole.

The second aim, which is to make users bear the total expenditure necessary to ensure the creation and operation of the means of communication, is supplemented by a definition of the goal pursued, which is to ensure a volume of investment in transport infrastructure advantageous to the economy as a whole.

Article 2, paragraph 1

As with the first Recital, the European Parliament proposes adding to the phrase "to promote the best possible use of the infrastructures" a form of words which sets out more clearly the aim pursued by the proposal for a decision.

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Article 2, paragraph 2

This paragraph provides that the Council is to adopt rules for calculating the marginal social costs and the equalizing charges. Since these rules are essential to ensure the fair operation of the whole of the system, the European Parliament asks to be consulted before they are fixed. Although the Economic and Social Committee has not made a request to this effect, it is proposed to consult it also in the same conditions.

Article 5

This article states that if the system of charging for the use of infrastructure is to function satisfactorily, independent operating bodies must be set up, provided with all the necessary powers to ensure that infrastructure is managed in conformity with the objectives and principles of the aforesaid system, and that each of these bodies be responsible for setting its charges on the basis of the cost and use of the infrastructure under its control. The European Parliament requests that an addition be made to the wording of this article in order to ensure that the principles of marginal social cost and balanced budgets are applied to these particular cases too.

Article 6, paragraph 1

Paragraph 1 of this Article defines the means by which the system of charging for the use of infrastructure is to be implemented. It provides that charges for the use of inland waterways be limited to navigation dues. The European Parliament requests that the possibility of imposing taxes on ships be also left open.

Article 7, paragraph 1

This Article states that in view of its complexity, the large number of implementing measures required and the wide-ranging economic and financial effects, a system of charging for the use of infrastructure can be established only by stages. The Commission considers that the problems arising here are

far greater for inland waterways than for roads, and has therefore allowed an additional period of five years for completing the establishment of a charging system in this sector. The European Parliament considers that the provision of two different transition periods for these two modes of transport will be liable to create certain distortions of competition both between the two modes of transport and between them and the railways. As competition does in fact exist between these three modes of transport on certain links, there is a risk of seriously complicating the calculation of compensating grants envisaged for the railways in paragraph 4 of this article, and even of handicapping road transport, for which no compensating grant is proposed. Parliament therefore proposes a single transition period of 15 years for both the modes of transport.

Article 7, paragraph 4

This paragraph makes provision for the payment of compensating grants to railways during the period of establishment of the charging system, in order to offset the handicap which they will suffer as long as their road and waterway competitors are not bearing the whole burden of the infrastructure costs attributable to them. The European Parliament proposes to supplement this paragraph in order to ensure that these compensating grants are deducted from the subsidies which various Member States grant to railways.

Other amendments of an editorial character have also been made to the proposal for a decision in question.



Amendment to the proposal for a decision  
on the introduction of a common system of charging  
for the use of transport infrastructure

The proposal for a decision of the Council presented by the Commission on 29 March 1971 is amended as follows:

- by an amendment to the first recital and the introduction of a new recital after the first recital,
- by an amendment to the third recital,
- by an amendment to Article 1,
- by an amendment to Article 2(1), ~~sub-paragraph 1~~
- by an amendment to Article 2(2),
- by an amendment to Article 5,
- by two amendments to Article 6(1), first and second indents,
- by an amendment to Article 7(1), ~~sub-paragraph 1~~
- by an amendment to Article 7(4),
- and also by certain purely editorial amendments.

These amendments are indicated in the attached document

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Original text

Amended text

THE COUNCIL OF THE EUROPEAN  
COMMUNITIES,

THE COUNCIL OF THE EUROPEAN  
COMMUNITIES,

Having regard to the Treaty estab-  
lishing the European Economic  
Community and in particular its  
Article 75;

No change

Having regard to the proposal from  
the Commission;

Having regard to the Opinion of the  
European Parliament;

Having regard to the Opinion of the  
Economic and Social Committee;

Whereas the introduction of a common  
transport policy entails the estab-  
lishment of a common system of  
charging for the use of infrastructure;  
whereas such a system must apply to  
rail, road and inland waterway infra-  
structure in such a way as to ensure  
fair conditions of competition in  
transport;

Whereas the introduction of a common  
transport policy entails the establish-  
ment of a common system of charging  
for the use of infrastructure;  
whereas such a system must apply  
initially to rail, road and inland  
waterway infrastructure in such a way  
as to ensure fair conditions of  
competition in transport;

Whereas this system must be established  
in such a way that it can in due course  
take in the other modes of transport, or  
so that its principles are capable of  
being applied to these other modes of  
transport, bearing in mind their particular  
features;

./.

Original text

Amended text

Whereas the introduction of a system of charging for the use of infrastructure requires a large number of measures which can be adopted and implemented only by stages; whereas, however, in order to facilitate the preparation of implementing measures and to promote coordination of national policies, the guidelines and general principles for such a system should be laid down now;

Whereas the system of charging must satisfy the dual aim of promoting the best use of existing infrastructure and of ensuring that all expenditure necessary for the construction and operation of the lines of communication is borne by the users thereof; whereas this objective will be attained if the charges for various categories of traffic are fixed according to the relevant marginal social cost, with the addition, where necessary, of an amount sufficient to ensure that the total expenditure in respect of the infrastructure in question is covered by the revenue from the use thereof;

Whereas in order to ensure that existing capacity is put to optimum

No change

Whereas the system of charging must satisfy the dual aim of promoting a distribution of transport among the different means and infrastructures which will be advantageous to the economy as a whole, and of ensuring that all expenditure necessary for the construction and operation of the lines of communication is borne by the users thereof, thus ensuring a volume of investment in transport infrastructure which will be advantageous to the economy as a whole; whereas this dual aim will be attained if the charges for ~~the various categories of~~ traffic are fixed according to the relevant marginal social cost, with the addition where necessary of an amount ("equalizing charge") sufficient to ensure that the total expenditure in respect of the infrastructure in question is covered by the revenue from the use thereof;

Whereas in order to ensure that existing capacity is put to optimum

Original text

Amended text

use, it is desirable that as far as possible the charges applicable to the various categories of traffic be adjusted to take account of variations in the marginal social costs relating to those categories;

use, it is desirable that as far as possible the charges applicable to the various categories of traffic be adjusted to take account of (two words deleted) the marginal social costs relating to those categories;

Whereas the means should be defined whereby the system of charging for the use of road and inland waterway infrastructure is to be implemented; whereas, as regards private cars, the possibility of imposing an additional charge should be allowed for, the level of such charge to be fixed having regard, in addition to budgetary requirements, to various social and other considerations;

No change

Whereas it is necessary to fix now the duration of the period during which the common system of charging for the use of road and inland waterway infrastructure is to be gradually established, account being taken of the effect of the proposed measures on competition between modes of transport; whereas, however, provision should be made to enable the programme and timetable to be drawn up by the Council for this purpose to be amended as necessary in accordance with the results obtained;

No change

Whereas, in order to create fair conditions of competition between modes of transport as from the period while the common system is being established,

Whereas, in order to create fair conditions of competition between modes of transport during the period while the common system is being established,

Original text

Amended text

it is necessary to make provision for payment of compensating grants to railway undertakings where the expenditure on road and inland waterway infrastructure is not borne in full by the users of that infrastructure;

it is necessary to make provision for payment of compensating grants during this period to railway undertakings where the expenditure on road and inland waterway infrastructure is not borne in full by the users of that infrastructure;

Whereas the possibility cannot be excluded of serious economic and social difficulties occurring in particular sectors of the economy of a Member State following implementation of the system of charging for the use of infrastructure; whereas it is necessary to provide for temporary derogations from the common provisions to deal with such difficulties and to define the procedure for authorizing such derogations;

No change

Original text

Amended text

HAS ADOPTED THIS DECISION:

HAS ADOPTED THIS DECISION:

Article 1

Article 1

There shall be introduced within the Community, in the manner and within the time limits laid down in this Decision, a common system of charging for the use of infrastructure for the purposes of transport by rail, road and inland waterway.

There shall be introduced within the Community, in the manner and within the time limits laid down in this Decision, a common system of charging for the use of infrastructure for the purposes of transport by rail, road and inland waterway.

This system shall be so designed as to be capable of being extended, in due course to the other nodes of transport.

Article 2

Article 2

1. The aim of such a system of charging shall be to promote the best possible use of infrastructure, while generating sufficient revenue to cover all expenditure on such infrastructure attributable to its transport function.

1. The aim of such a system of charging shall be to generate sufficient revenue to cover all expenditure arising from the use of infrastructure and attributable to the transport function thereof.

At the same time, the system of charging must promote an even distribution of traffic between the various infrastructures and a volume of investment in transport infrastructure advantageous to the economy as a whole.

To this end, the charges applicable to the various categories of traffic must be equal to the marginal social cost of the use of infrastructure by those categories. Should the revenue produced by such charges be less than

To this end, the charges applicable to the various categories of traffic must be equal to the marginal social cost of the use of infrastructure by those categories. Should the revenue produced by such charges be less than the total

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Original text

Amended text

the corresponding expenditure, there shall be added to the marginal social cost an equalizing charge, the amount of which shall be such as to ensure that the said expenditure is covered.

2. The Council, acting by a qualified majority on a proposal from the Commission, shall lay down rules for calculating the marginal social costs and the equalizing charges.

expenditure on the infrastructures concerned, there shall be added to the marginal social cost an equalizing charge, the amount of which shall be such as to ensure that the said expenditure is covered.

2. The Council, acting by a qualified majority on a proposal from the Commission, and after the Parliament and the Economic and Social Committee have been consulted shall lay down rules for calculating marginal social costs and equalizing charges.

Article 3

Article 3

The expenditure within the meaning of Article 2(1) to be covered over a specified period by the revenue arising during that period shall comprise the following expenditure incurred during that period:

- investment expenditure (expenditure in respect of construction, reconstruction and replacements of installations);
- current expenditure (expenditure on the maintenance and operation of such installations and on administrative services).

Where investment expenditure is financed by borrowing, the revenue raised by charging must, over a specified period, be equal to the sum of the following two items:

No change

Where investment expenditure is financed partly or wholly by borrowing, the revenue raised by charging must, over a specified period, be equal to the sum of the following two items:

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Original text

Amended text

- expenditure incurred during the period in question not covered by borrowing;
- repayments and interest charges attributable to the period in question in respect of loans contracted earlier to finance investment expenditure.

No change

Article 4

Article 4

The scale of charges for the use of infrastructure shall differentiate to the utmost between categories of traffic having different ~~marginal-social~~ costs. Within each category of traffic separate charges shall be applied wherever this is justified by variations of time and place in the use of infrastructure and is possible, having regard to the cost of collection, with the means available.

No change

Article 5

Article 5

Separate charges for the use of infrastructure shall be fixed in respect of engineering works, routes or networks operated as separate entities.

Separate charges for the use of infrastructure shall be fixed in respect of engineering works, routes or networks operated as separate entities.

These charges shall be based on the principles laid down in Articles 2, 3 and 4.

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Original text

Article 6

1. The system of charging for the use of infrastructure shall be implemented by the following means:

- in respect of roads, by means of vehicle taxes, fuel taxes and measures for direct charging;
- in respect of waterways, by means of navigation dues.

2. The use of vehicle taxes and fuel taxes as means of charging for the use of infrastructure shall not prevent the imposition, in particular to meet taxation requirements, of additional charges on ownership of private vehicles or on consumption of fuel used by such vehicles.

Article 7

1. The system of charging for the use of infrastructure shall be established by stages. Subject to any extensions authorized by the Council under paragraph 3 hereof, establishment of the system shall be completed by not later than 31 December 1981 in respect of roads and by 31 December 1986 in respect of waterways.

Amended text

Article 6

1. The system of charging for the use of infrastructure shall be implemented by the following means:

- for the use of roads, by means of vehicle taxes, fuel taxes and measures for direct charging;
- for the use of inland waterways, by means of navigation dues, and where appropriate, taxes on vessels.

No change.

Article 7

1. The system of charging for the use of infrastructure shall be established by stages. Subject to any extensions decided by the Council under paragraph 3 hereof, establishment of the system shall be completed not later than fifteen years after the entry into force of the present Decision.

Original text

Amended text

The timetable of the stages and the measures to be taken during each of these shall be laid down by the Council on a proposal from the Commission.

No change

2. If during the period of establishment of the charging system the application of measures prescribed for any stage gives rise to serious economic or social difficulties in any sector of the economy, the Commission may, at the request of a Member State and after consulting the other Member States, authorize, for a limited period, derogations from these measures. Disturbances caused by such derogations to the establishment of the system must be kept to a minimum, and the derogations must not go beyond what is strictly essential to remedy the difficulties found to have arisen.

No change

3. Before the end of each stage the Commission shall present to the Council a report on the results of the measures applied during that stage. In particular, the report shall record any derogations granted under paragraph 2 and shall if necessary be accompanied by proposals to extend the duration of the stage in question or to amend the measures to be implemented during the following stage.

3. In good time before the end of each stage, the Commission shall present to the Council a report on the results ~~observable~~ at the time ~~when the report is prepared~~ of the measures applied during that stage. In particular, the report shall record any derogations granted under paragraph 2 and shall if necessary include proposals to extend the duration of the stage in question or to amend the measures to be implemented during the following stage.

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Original text

4. During the period of establishment of the charging system, compensating grants calculated in accordance with common rules to be laid down by the Council on a proposal from the Commission shall be paid to the railway undertakings in order to offset the fact that the expenditure on road and waterway infrastructure is not borne in full by the users thereof.

Article 8

This Decision is addressed to the Member States.

Amended text

4. During the period of establishment of the charging system, compensating grants calculated in accordance with common rules to be laid down by the Council on a proposal from the Commission shall be paid to the railway undertakings in order to offset the fact that expenditure on road and waterway infrastructure is not borne in full by the users thereof. These compensating grants shall be deducted from the public subsidies granted in the Member States.

Article 8

No change

Annex II

Approaches to urban congestion cost determination

### Introduction

1. In looking at a system of charging for the use of infrastructures (T.U.I.), urban traffic congestion is much more important than congestion occurring outside built-up areas. Moreover amongst the various costs associated with urban congestion, time lost is most probably the most important aspect.

To keep matters simple and to allow faster progress, this paper will concentrate on measuring the cost of time lost due to urban congestion.

2. In dealing with the measurement of time losses due to urban congestion and with their value, the paper does so from the marginal cost viewpoint which represents the basic idea in T.U.I. In order to have a single unit for all types of infrastructure costs, marginal costs are expressed per vehicle-kilometre.

3. The conclusions in this paper are based on previous work done by the Urban Studies Sub-Group on problems involved in measuring speed-flow relationships (doc. C/CEU/02-70), the Giunti report stemming from the Sub-Group's conclusions (doc. C/CEU/14-70) and the Urban Studies Sub-Group on the value of time (doc. C/CEU/13-70), as well as the discussions on the studies carried out in the cities of Bruxelles, Cologne, Lyon and Verona.

### Basic concepts and definitions

4. Marginal costs of congestion are really those costs which are incurred by traffic in a defined area (a single stretch of road or a "zone") as a result of the addition to existing traffic of an extra vehicle. However, for the purpose of cost determination it is simpler to restrict marginal congestion costs to those incurred by the other vehicles as a result of adding one vehicle, and thus to ignore the extra cost incurred by that marginal vehicle itself.

5. In order to ascertain these marginal costs, both the quantity (in hours) and the value of time (in money per hour) must be known. These factors are dealt with in more detail in the paragraphs that follow, both as regards basic formulae and various methods of measurement appropriate to different circumstances.

6. (a) The total time (in hours) spent by traffic in a defined area results from knowing :

- the length of the road or extent of the area (kms)
- the average speed (km per hr)
- the flow (i.e. number of vehicles per hour).

(b) The marginal change in this total time due to the introduction of an extra vehicle is obtained by the mathematical process of differentiation (e.g. by measuring the rate of change in speed as against flow).

(c) In traffic conditions before saturation point is reached, i.e. : where stop and go traffic has not yet started, all observations show that as the volume of traffic increases, the speed drops. Since such a phenomenon can best be expressed in mathematical or statistical terms, the attached appendix shows how the formulae are derived from the original relationships.

(d) The appendix shows that :

over a stretch of 1 km, the marginal extra time spent by other traffic per extra vehicle added, i.e. the marginal time loss

$$= - \frac{q}{v^2} \cdot \frac{dv}{dq}$$

where  $q$  = flow

$v$  = average speed

and  $\frac{dv}{dq}$  = the rate of change in speed with respect to flow.

(e) This approach is one well known method of measuring time loss; others with similar mathematical backgrounds, but concentrating on different traffic variables may also be applied (see paras 9-13).

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7. Having developed one or more satisfactory formulae for measuring the marginal loss of time, the question may be asked whether each vehicle has the same effect, or whether large and often slower commercial vehicles cause more congestion than say private cars. This is the question of vehicle equivalence coefficients (see para. 14 below).

8. Having dealt with the measurement of time, the following elements must be taken into account when assessing its value per vehicle/km :

(a) the value of time for a road user (monetary value per hour)

(b) the number of users per vehicle (degree of occupancy).

These elements are dealt with in greater detail in paras 15 to 20.

#### The measurement of time losses

9. The studies carried out on Brussels, Cologne, Lyon and Verona have shown that there is no universally practical method for measuring time losses. It may well be that different methods are most useful in different local circumstances and conditions especially where congestion is measured on "links" i.e. single road stretches, or "zones" i.e. homogeneous areas each with own particular characteristics. The following paras therefore deal in order with methods based on :

(a) speed-flow

(b) speed - density

(c) zone traffic performance

(d) intersection delay.

10. Speed-flow relationships may be seen as having two distinct aspects viz. :

- stable flow

- unstable flow

which are illustrated by the form of a typical speed-flow curve as shown in the Giunti report (C/CEU/14-70). The upper part of the curve representing stable flow, indicates the steady decrease in speed in relation to increasing

./.

traffic volumes up to the saturation point at which unstable flow commences : As one would expect time lost is a positive quantity up to the saturation point.

As concluded in the Giunti report only the upper part of the speed-flow curve should therefore be used as the values determined from this part are reliable, and meaningful time losses can be calculated.

An unstable flow situation develops beyond the point of saturation i.e. when speed and flow decrease erratically and can therefore not be dealt with satisfactorily by speed-flow relationships. These phenomena are dealt with in the next para on speed-density.

11. Traffic density may be defined as the number of vehicles occupying a unit length of road at any given instant; it is usually expressed as vehicles per kilometre. It may be more convenient in some instances to use average density which is the average number of vehicles per unit length of road over a specified period of time, e.g. the average concentration of vehicles per kilometre during an hour.

Traffic speed decreases steadily with increasing density throughout the speed range. Put another way density continues to increase at and beyond the flow saturation point and is then detected by the user as an increased rate of queuing. It therefore appears that speed-density relationships remain reasonably stable in unstable flow conditions and they could therefore have some overall advantages as compared with speed-flow relationships, when considering heavily congested traffic conditions.

The mathematical relationship is also dealt with in the attached appendix.



12. Speed-flow and speed-density concepts as described above are particularly useful in looking at single road stretches (links).

A different concept is to divide the urban area into a series of homogeneous zones and to measure the amount of vehicle travel being performed in a zone i.e. the zone traffic "performance" defined as the number of kilometres being driven by vehicles in the zone during a specified time.

This "performance" is reflected in the number of vehicles in motion (non-parked) in the zone during the same specified time and the average overall travel speed being attained in the zone. By equating these two elements, as shown in the appendix, and measuring the zone traffic "performance" and the number of vehicles in motion (non-parked) the average overall zone travel speed can be calculated.

From the mathematical standpoint, the average overall zone travel speed is a simple declining function of the total number of vehicles in motion (non-parked) in the zone. Thus, as before, the rate of change of speed with respect to vehicle numbers ( $\frac{dV}{dn}$ ) is always negative and the marginal time loss per vehicle per kilometre is always positive (see appendix).

13. The fourth approach is based on the premise that intersection delays are the main source of traffic delay in urban areas. Congestion is a function of the frequency of occurrence of heavily loaded intersections.

It would seem that different bases must be used for calculating the delays at overloaded intersections (where there is a continuous queue) and underloaded intersections. From these figures the total and marginal time losses may be determined on an area-wide basis.

It is hoped to present a separate paper giving a more detailed explanation of this method at a later stage.

#### Vehicle equivalence

14. In para 7 the question was raised whether large vehicles would cause significantly greater congestion in the traffic stream than the smaller kind. If so, an allowance could be made by substituting for each large

vehicle a theoretical number of cars which it is estimated would have the same effect on the traffic stream as the large vehicle.

At the low speeds usually encountered in heavily congested urban traffic, and bearing in mind the low proportion at peak times of heavy vehicles (except possibly buses), it seems doubtful whether a heavy vehicle contributes significantly more to congestion than a car. It therefore appears to be acceptable to consider all vehicles equal. Alternatively a value of 1 for cars, small vans and light trucks and a value of 2 for heavy trucks and buses has been suggested. This approach avoids the problems of accurately and scientifically determining features such as dynamic profiles, overall dimensions etc. in relation to low speeds, and seems justified on the basis of simplicity versus doubtful accuracy.

#### The valuation of time losses

15. As regards the value of time for each vehicle user, a Sub-Group of the Urban Studies Group examined various aspects of time value in 1970. Amongst other things they discussed:

- the feasibility of valuing users time on a large scale
- the comparison of gains and losses
- the different user categories
- the valuation of working time, commuting time and leisure time
- the differences in value between morning and evening peaks and other periods, both on working days and Saturdays and Sundays
- the valuation of the time of commercial and public transport vehicles and, as regards the latter, the increase in cycle time and the consequent increase in vehicle fleets required to maintain a defined level of service.

16. The Sub-Group noted the lack of research on these problems and agreed that the most useful contribution was the 1969 Sixth Round table on Transport Economics devoted to the value of time sponsored by the European Conference of Ministers of Transport. The Sub-Group therefore made the following recommendations, largely based on the findings of the Round Table:

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- (i) marginal value = average value
- (ii) working rate = rate of gross earning plus employment taxes, social welfare contributions etc. plus 10% to 15% of rate of gross earnings for overhead expenses
- (iii) commuting time = 25% of working rate in (ii) (morning peak only)
- (iv) other time = commuting time as stated in (iii)

The question of how to evaluate the evening peak traffic period was not decided by the Group.

17. To take these recommendations one step further and bearing in mind the ultimate need for a simple and effective approach, it may be useful to consider only two of the above categories of time i.e. working and non-working time, the former valued as in (ii) above and the latter at 25% of the working rate. This would leave the question of how to differentiate in practice between working and non-working time.

18. In certain cases nationally agreed values of time are available, based on the above reasoning. In some cases these values are in terms of "disposal income" i.e. gross earnings less taxes and social contributions. Where this is the case a comparison of the monetary values is likely to show closer approximations than a comparison of the basic concepts.

#### Vehicle occupancy

19. Finally it is necessary to know on average the number of users in each vehicle. It has been considered useful to concentrate on private cars and to ignore for purposes of simplification both the occupancy of buses and traffic during holiday periods etc. If this is borne in mind, an average rate for urban areas at times of significant congestion appears to lie in the range of 1.3 to 1.5 occupants per vehicle.

Annex

Appendix

Mathematical Relationships

Introduction

1. The basic approach as mentioned in the main text is the valuation of time lost, i.e. more specifically, the product of the following two elements :

- the marginal loss of time per vehicle per kilometre
- the value of time per vehicle.

Measurement of time losses

Speed-flow

2. The total time spent by vehicles in the traffic system per hour may be expressed as

$$T = \frac{l}{V} \cdot q \dots\dots\dots (i)$$

- where  $l$  = length of traffic system (km)
- $V$  = average speed of vehicle flow (km/hr)
- $q$  = vehicle flow per unit of time (veh/hr)

The marginal change in the total time ( $T$ ) caused by the arrival of one additional vehicle in the system is :

$$\frac{dT}{dq} = \frac{1}{V} - \frac{1}{V^2} q \frac{dV}{dq} \dots\dots\dots (ii)$$

which is composed of two elements viz.

$\frac{1}{V}$  = time spent by one additional vehicle in the system

$-\frac{1}{V^2} q \frac{dV}{dq}$  = additional time spent by the other vehicles in the system as a result of the arrival of one additional vehicle i.e. the marginal time loss for all the other vehicles per additional vehicle.

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If a value of unity is assumed for l, say 1 km, then the general expression for the marginal time loss per additional vehicle per kilometre as a function of flow is :

$$T_{mq} = - \frac{q}{v^2} \frac{dv}{dq} \dots\dots\dots(iii)$$

This formula may be rearranged as follows :

$$T_{mq} = - \frac{1}{v} \cdot \frac{\frac{dv}{dq}}{\frac{v}{q}} \dots\dots\dots(iv)$$

The  $\frac{\frac{dv}{dq}}{\frac{v}{q}}$  factor which results from this rearrangement is considered to be

a more stable indicator, i.e. a shorter range of values, of traffic behaviour on a particular link than the wide range of speed/flow values with which one is presented otherwise when considering heavily congested conditions. It is interesting to note that the  $\frac{v}{q}$  term is the reciprocal of traffic density.

Speed-density

3. The total time spent by vehicles in the traffic system may be expressed as

$$T = \frac{l}{v} \cdot n \dots\dots\dots(v)$$

- where l = length of traffic system (km)
- v = average speed of vehicles (km/hr)
- n = number of vehicles (veh/km)

Differentiating as before in para 2, it can be shown that the general expression for the marginal time loss per additional vehicle per kilometre as a function of density is :

$$T_{mn} = - \frac{n}{v^2} \frac{dv}{dn} \dots\dots\dots(vi)$$

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Zone "performance"

4. The total urban area may be divided into homogeneous zones, each with its own particular characteristics.

The amount of vehicle travel in a zone i.e. the zone traffic "performance" may be defined as the number of kilometres being driven by vehicles in the zone during a specified time, say vehicle-kilometres of zone travel per hour.

The zone traffic performance is considered to be equal to the number of vehicles in motion (non-parked) in the zone multiplied by the average overall zone travel speed.

The relationship may be written as:

$$nV = P$$

or  $V = \frac{P}{n}$  .....(vii)

- where  $v$  = average overall zone travel speed (km/hr)
- $P$  = zone traffic performance (veh-km)
- $n$  = number of vehicles in motion in the zone during one hour.

The purpose of this approach is to arrive at a value for the average overall zone travel speed.

The average overall travel speed in a particular zone is a simple declining function of the total number of vehicles in motion (non-parked) in the zone.

The total time spent by vehicles in the zone may be expressed as

$$T = \frac{k}{V} \cdot n$$
 .....(viii)

- where  $k$  = average trip length for all vehicles (km)
- $V$  = average overall zone travel speed (km/hr)
- $n$  = number of vehicles in motion in the zone during one hour.

Differentiating as before in para 2, it can be shown that the general expression for the marginal time loss per additional vehicle/kilometre as a function of average overall zone travel speed is :

$$T_{mz} = - \frac{n}{v^2} \frac{dv}{dn} \dots\dots\dots(ix)$$

The average overall zone travel speed is a simple declining function of the total number of vehicles in motion in the zone. Thus, the rate of change of speed with respect to vehicle numbers ( $\frac{dv}{dn}$ ) is always negative and the marginal time loss per vehicle per kilometre is always positive.

The valuation of time losses

5. The value of time factor to be used to convert the marginal time losses per additional vehicle per kilometre calculated by means of equations (iii), (vi) and (ix) consists of two elements, the average number of users per vehicle (a) and the average value of users time.

Thus the marginal cost of time per additional vehicle per kilometre in each case becomes :

where a = average vehicle occupancy (persons/veh)  
and h = average value of user's time (monetary value/hr)

in the case of flow,

$$C_{mq} = - \frac{q}{v^2} \frac{dv}{dq} \cdot ah \dots\dots\dots(x)$$

where q = vehicle flow per unit time (veh/hr)  
V = average speed of vehicle flow (km/hr)

in the case of density,

$$C_{mn} = - \frac{n}{v^2} \frac{dv}{dn} \cdot ah \dots\dots\dots(xi)$$

where n = number of vehicles per unit length of road (veh/km)  
V = average speed of vehicles (km/hr)

in the case of zone "performance",

$$C_{mz} = - \frac{n}{V^2} \frac{dV}{dn} \cdot ah \dots\dots\dots(xii)$$

where n = number of vehicles in motion in a zone during one hour

V = average overall zone travel speed (km/hr).

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Annex III

Study of noise and air pollution

by urban traffic

(V.D.I.)

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- Summary -

It is generally recognized today that traffic problems in urban areas cannot be solved by yet more streets, parking garages, car parks and other such facilities for controlling and regulating traffic. Instead, it is the task of those responsible for traffic and transport policy to contribute, through other appropriate measures, to as great a reduction as possible of the conflicts that have become evident between the traffic burdens on city centres and the living conditions in these areas.

An essential condition for effective action is the existence of aids for decision-making which, based on an analysis of the current situation, quantify the observable effects, reveal possible improvements and provide a general idea of the costs involved.

Such considerations have induced the Council of Ministers of the European Communities to initiate a study of environmental nuisance and damage caused by traffic in urban areas (noise and exhaust gases).

The research project was commissioned by the West German Minister for Transport on consultation with the Commission of the European Communities. The Association of German Engineers accepted the task and, in its turn, commissioned medical doctors, engineers and economists to study individual aspects of the problem.

The aim of this study was to develop a practicable method of estimating the marginal costs of environmental nuisance caused by noise and exhaust gases emitted by traffic in urban areas.

The report comprises a detailed general account (long version), and a short version, in which the main results are presented in concise form. Both versions include a "General Summary", which contains an introduction to the subject and informs the reader of the contents and composition of the report.

The following aspects were studied in the survey (separately for noise, and air pollution)

- current extent of the environmental burden,
- psychological and physiological effects of the environmental burden
- costs to the economy as a whole of the environmental burden and the proportion thereof accounted for by marginal costs.

The basis for ascertaining the current extent of the environmental burden caused by both noise and exhaust gases was provided by a model of a typical large European town. The model town was composed of 12 characteristic "town model building elements", which can be regarded as representative of the urban construction pattern in five selected large European towns (Amsterdam, Brussels, Cologne, Lyons and Verona). Typical traffic densities and traffic composition were determined for each of these basic elements.

## II.

Part I of the study deals with the noise burden caused by traffic in urban areas. On the basis of the acoustic relationship between traffic volume, urban construction pattern, noise creation and noise expansion and diffusion, the noise immissions to be expected at typical points of the urban construction pattern could be determined.

In the study, the criteria used for traffic noise immissions are the energy equivalent continuous noise level  $L_{eq}$ , generally employed to distinguish sounds whose noise level varies with time, and the level  $L_1$ , corresponding to isolated peaks.

The  $L_{eq}$  and  $L_1$  level values were determined for characteristic points on building facades, always at an open window. The actual level of the immitted noise within the building can be derived from the external level, allowance being made for the reduction in sound level due to the shielding effect of the window.

The effects of noise on people depend on the level of the imitted noise. They extend from impairing performance particularly where attentiveness and a high degree of concentration is required to - in especially serious cases - temporary malfunctioning of the hearing organs and to noise deafness.

Such effects on man's health and well-being can be avoided by observing imission guide values, or target levels, based on the threshold of perception of the noise effects.

Such guide values at various levels are suggested in the study for the relevant "spheres of activity" in urban living space. In respect of nuisance caused by traffic noise, the main "spheres of activity" to be considered are "dwelling", "sleeping", "recreation", "communication" and "mental exertion".

Since the street area itself forms part of the urban living space of man (the way to the place of work, shopping excursions, etc.), efforts should also be made here to avoid deleterious effects by observing certain target levels. Guide values for this purpose are also given in the study.

In determining the costs of the noise burden to the economy as a whole, as well as the proportion accounted for by marginal costs, preventive costs were chosen, since the current state of scientific development does not permit direct monetary quantification of the damage caused by traffic noise which affects man's level of satisfaction, health and life expectancy.

Measures suitable for avoiding burdensome noise imissions can be taken directly at the source of emission (active preventive measures) or on the noise diffusion path from emission to imission (passive preventive measures).

To provide protection from excess noise in the immediate vicinity of the noise source as well (e.g. for pedestrians, car occupants, etc.) it seems reasonable to try out first all feasible ways and means of using active measures.

With this in mind, various technical solutions are presented in the study; at the same time the additional net capital costs of these measures for new motor vehicles are given, which can vary according to the kind of measures and the type of vehicle.

It proved possible to fix a representative average value for all types of passenger vehicles including station wagons. The report, taking into consideration the "noise relevant" distance covered annually, gives the specific costs of active sound insulation measures per passenger vehicle km by spreading the net capital outlay over the service life.

The experts have calculated that the energy-equivalent continuous noise level can be reduced by about 3 dB(A) if about half of all passenger vehicles are equipped with noise muffling devices. The demonstrated costs per passenger vehicle km therefore refer only to the relatively louder part of the vehicles present in any given traffic stream; in the study, it is considered admissible to regard this value as approaching the marginal cost value per passenger vehicle.

The marginal costs for trucks of more than 3.5 t permissible total weight were determined from those for passenger vehicles by means of weighting factors.

With heavy traffic, the reductions in noise level that can be achieved through active measures are as a rule quite inadequate to reach the medically desirable target levels in the bedrooms, living rooms and work rooms of buildings that border on traffic areas. In such cases, additional passive protective measures against noise are called for.

The study refers to various methods of affording passive protection against noise and also shows their effectiveness. It is demonstrated that the best noise damping effect in buildings can be achieved by installing special sound-insulating windows. Since, in many cases, the installation of such windows is the only means of affording effective protection against noise, the experts derive the costs for passive protective measures from noise reduction by means of special windows.

The type of window construction needed is determined by the difference between the actual and desired noise level. From the sum of the window surface areas to be protected in each "town model building element", the investment outlay for passive protective measures can be calculated, first for the individual elements and finally, by summation, for the model town as well.

The EC Survey into ways and means of reducing noise also revealed that, in addition to technical vehicle improvements and their associated costs, various other deficiencies should be eliminated and loopholes in the law closed. The following measures seem to be especially suitable:

- the introduction of a suitable method of noise measurement to enable the Technische Überwachungsvereine (Technical Inspection Associations) to check the actual noise emission of a motor vehicle on the occasion of the two-year test;

- supplementing existing regulations for the construction and testing of inlet and exhaust silencers to promote the production of environmentally favourable types;
- enlightening motorists about driving behaviour benefitting the environment;
- establishing internationally agreed uniform legislation, particularly for regulations on licensing and type of construction, together with similar technical inspection procedures in all countries.

Such complementary measures can be taken independently of the appropriate active measures, and often have the additional advantage that they can be introduced at relatively short notice and comparatively low cost.

### III.

Part II of the study deals with the exhaust gas burden caused by traffic in urban areas. The environmental burden from exhaust gas emission is affected by, on the one hand, traffic characteristics (e.g. traffic density, average speed) and, on the other, by vehicle factors (e.g. engine, functioning, fuel charge mixing). In the course of the study, the average emission values of motor vehicles were empirically determined through simulation of the driving conditions observed in city traffic on a testing circuit.

Emissions need to be set against their environmental effects, i.e. immissions. For this purpose, immissions of the exhaust gas component carbon monoxide, which served as a guide component, were measured in the urban area of Cologne. The choice of streets for the measurements was guided by the "town model building elements" developed for this study.

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On the basis of these measurements, daily curves were drawn for the carbon monoxide concentration at the different measuring points, from which half-hour and 24 hour mean values of the CO concentration at each measuring point on each day of measurement could be calculated.

If the exhaust gas immissions exceed specific limit values, damage to human health may occur. Such limit values are proposed in the study for various exhaust gas components, and in particular, for the carbon monoxide content in the air. From the medical standpoint, substantially higher values are regarded as permissible for the half-hour mean value than for the 24-hour mean value.

The highest permissible emission values corresponding to the reduced immission values were determined on the basis of a method showing a reduction in traffic density.

The costs of the environmental burden of motor vehicle exhaust gases to the economy as a whole were, as in the case of the environmental noise burden, quantified with the aid of an avoidance cost estimate; the capital costs of technical vehicle modifications to ensure observance of immission limit values were determined.

The additional expenditure on new vehicles with reduced emission values is quoted in the study. This net investment outlay was spread over the service life of the vehicle and then applied to the "exhaust-gas relevant" distance covered annually, resulting in specific costs of the environmental burden from exhaust gases per passenger vehicle-km.

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IV.

The experts have endeavoured to fulfil their task in the most comprehensive manner possible. This study, which was assembled by representatives of the different disciplines working in close-cooperation, thus provides a wealth of hitherto unavailable data and insights into mutually interdependent phenomena. On the other hand it also reveals the areas in which, in view of the complexity of the problems to be solved, further studies are necessary to confirm the results presented for individual aspects.

A particular problem is the extent to which the results obtained apply in other Member States of the European Communities. The study presented was very largely based on statistical data and quantities valid for West-Germany. The discussions to be expected following publication of the study should show the extent to which the conclusions to be drawn from the report are also valid for other EC countries.

These discussions will doubtless also lead to further refinement of the initial solutions presented in the research report, to enable the gaps still remaining to be filled and to pave the way for a methodology of calculating environmental costs which could be used in a comparable manner in all Member States.

ANNEX IV

INFRASTRUCTURE CHARGING AND THE SELECTION OF  
INFRASTRUCTURE INVESTMENTS

- Summary -

INFRASTRUCTURE CHARGING AND THE SELECTION OF  
INFRASTRUCTURE INVESTMENTS

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(Summary of the Report by  
Professors K.M. GWILLIAM and J.A. ZIGHERA)

Introduction

1. The following paragraphs summarise and reflect the views of Professors Gwilliam and Zighera as expressed in the report which they were asked to prepare by the Directorate-General for Transport of the Commission.

Aims

2. The theme of the report as stated by the authors is to "investigate the relationship, both in theory and practice, between, on the one hand, marginal social cost pricing combined with a budgetary equilibrium system, and on the other hand, the selection of infrastructure investments".

3. Their study is derived from the report on the "Coordination of investments in transport infrastructure (GPVZ) (1). Its aims are to reveal and classify possible contradictions rather than attempt to find solutions; however, the study is not intended to be purely theoretical and should throw light upon the practical methods available to improve upon current policies.

Infrastructure Charging

4. The system of marginal social cost, with budgetary equilibrium, originated in the Allais Report (2). Based on this report, together with that of "Malcor" (3) and the Paris-Le Havre pilot study, the Commission submitted a proposal

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- (1) By Professors Gwilliam, Petriccione, Voigt and Zighera (Doc. 332/VII/72 rev. 1)  
(2) "Options de la politique tarifaire dans les transports" by Prof. Allais, del Visco, Dusquesne de la Vinelle, Oort and Seidenfus, Etudes série Transports, EEC Brussels 1965 - 1  
(3) Problèmes posés par l'application pratique d'une tarification pour l'utilisation des infrastructures routières. Etudes série Transports, EEC Brussels 1970 - 2

to the Council for the "introduction of a common system of charging for the use of transport infrastructure" (1). It is useful to distinguish the aspects of marginal social pricing on the one hand and budgetary equilibrium on the other hand.

5. Marginal social cost is considered to have been clearly defined and divided into three categories:

- marginal costs of use: made up of maintenance, renewals, operation and management;
- marginal congestion costs: made up of time losses, waiting time, increased consumption (all external to the mode);
- marginal external costs, which covers accidents, noise and pollution, as well as the interaction between modes.

6. Budgetary equilibrium, although seemingly adequately defined in principle has not been defined with sufficient clarity in its methods of application. The definition of sub-groups, each of which must be subjected to the constraint of budgetary equilibrium, is not clearly made except to the extent that they must be unimodal and regional. Moreover the problems of imputing the difference between the total of marginal costs and the receipts necessary for budgetary equilibrium to the different categories of users need to be dealt with. There are thus some reservations concerning the compatibility of marginal social costs and budgetary equilibrium.

#### Investment Choice

7. The policy for the coordination of investments is much less developed than that for infrastructure charging. The GPVZ report referred to in para 3 is based on the following philosophy:

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(1) COM(71)268 final.

- investment choice should be preceded by a comparison of the discounted costs and benefits of the various alternatives,
- public investment decisions take into account objectives which cannot be measured in market price terms, or only partly so. Special methods to measure such objectives must therefore be developed. Where these methods are open to doubt and to the extent that such objectives become important, it is vital that the decision-making process should be as clear and as transparent as possible.

As indicated for infrastructure charging above, some questions remain on the compatibility of these two strands of the authors' reasoning concerning the choice of investments: they have been partly discussed in the GPVZ report.

#### Setting of values

8. The investment choice problem forms one part of the transport decision making process, in the context of which there are numerous factors which are not commensurable or even quantifiable. On the other hand, infrastructure pricing questions are also part of the decision making process, and the very process of setting prices implies that society has placed a value on some at least of the non-commensurable and non-quantifiable elements. Both in pricing and in project evaluation such values are often derived from the behaviour and judgement of institutions and of users, be it to a different degree.

#### Conclusions

9. Before dealing with the conclusions proper of the reports it should be noted that there is nothing in the study to question the basic principles of infrastructure pricing adopted by the Commission, and any possible improvements stemming from the report's recommendations do not justify delay to decisions being considered currently.

10. The importance of pricing for the optimum use of infrastructure is clear. It is also clear that, especially in congestion situations, the pricing regime adopted or proposed will substantially affect the apparent desirability

of infrastructure projects. The crucial problem is that of defining what really is the social optimum when the full range of objectives and inter-relationships is taken into account. Hence, especially where external effects are prevalent, the definition of an optimal price system is very difficult.

11. In attempting to define this optimum price system one may adopt the theory that prices should be set in such a way that full costs of infrastructure should be covered and that this should be achieved in such a way as to minimise the distortion away from that utilisation which would result if prices were everywhere equal to marginal social cost. But there is a lack of both the knowledge about demand elasticities for various traffics and the instruments of price discrimination necessary to feel satisfied that this "minimum distortion" outcome can ever be reached.

12. Cost benefit analysis techniques already developed allow the identification of good investment projects at a very general level. It is not presently possible to quantify precisely the way in which decisions impact on the other objectives (e.g. environment, regional development etc.). But with the exception of the urban situation where the interactions are most complex, it is considered possible to describe expected affects with sufficient clarity to allow them to be taken into account sensibly in decision making. Moreover, in the inter-urban context, the rate of return on projects is not expected to be highly sensitive to the infrastructure pricing policies adopted. Hence it is believed that it is sensible to proceed with inter-urban projects by applying cost-benefit analysis and general evaluation methods independently of the progress made in the implementation of the pricing scheme.

13. The best use of urban transport facilities is more complex. It is neither simply a transport question nor a financial question, but is essentially connected with urban planning in the broadest sense. The complexity and magnitude of externalities excludes the possibility of any simple formula to achieve efficiency. Arbitrary financial rules are very likely to present problems in securing conformity between transport planning decisions and urban planning in general. If the proper consideration of planning options and available planning instruments shows that a certain traffic pattern is right

then this should take priority over any arbitrary financial target in infrastructure management. As a corollary of this, however, great care will need to be taken to ensure that this approach does not have consequential repercussions on inter-urban transport. It may be necessary to have separate financial regimes for urban and inter-urban organizations to ensure this.

14. For inter-urban traffic the externalities appear to be much less significant and in this context it seems that financial criteria set for each mode or organization, disaggregated spatially, could produce inducements to efficient use of resources. Each unit could seek financial adjustments in respect of external effects; the payment of such adjustments by national authorities would have to conform to community determined principles. But it does appear that, for this very substantial part of the transport sector that no insuperable difficulties arise from the inter-relationship of pricing and investment issues.