Freight transport models as a tool for management

by

J. VAN ES

Netherlands Institute of Transport

INTRODUCTION

1.1 General features of policy information systems

The transport industry as well as the government are continuously confronted with situations where they have to make decisions in order to reach certain future objectives. Those decisions can influence each other strongly and are to a more or less extent based on concrete policy targets and on the choice of specific policy instruments.

Policy information systems now do have the object to prepare the decisionmaking of the transport industry and the government in the best possible way. Decisionmaking however suggests that the objectives are formulated and the most efficient instruments are chosen in order to reach the mentioned objectives. This does not mean that the development of policy information systems has to wait on the ultimate formation of the policy targets and the determination of the instruments. In real live policy targets and the choice of policy instruments are subject to a process of evolution and can not be determined once and for all.

It must be clear that policymaking not only includes short term market policies, which can only react to given actual situations, but that it includes also medium and long term policies, which have the object to influence structural situations.

It will be clear too that policymaking is not only done by the government but that the developments in transport life are the combined results of the policies of transport firms, government and organized transport industry as well.

If a policy information system want to be a real help for policymaking, it must include two essential characteristics:

1. It must give actual information on transport and the underlying factors.
2. It must be based on the existing interrelations between the transport sector and the rest of the economy and on the interrelations within the transport sector itself.

The complementary position of freight transport in the overall economic life makes those interrelations very complex and multi-dimensional. This can be easily understood, considering that freight transport has to deal with:

1. a great diversity of economic activities

(production and consumption activities) each of which has its own very specific transport needs.

Supply and demand pattern per economic activity can differ strongly with respect to:

- transport volume per time unit
- commodity groups
- appearance of the cargo
- size of shipment
- geographical distance
- origin resp. destination
- technical organisation of the physical distribution process
- seasonal, conjunctural and structural dependencies etc., etc.

2. An environmental dispersion of the economic activities

Which influence considerably the geographical transportation pattern. That is to say the realized need for transport per commodity group. Changes in the environmental dispersion can influence the transport pattern on the medium and the longterm the transport pattern in a great deal.

3. The possibility of using different modes of transport for the carriage of goods (road transport, rail transport, inland navigation, maritime transport and so on).

To some extent these transport modes compete with one another and to some extent they complement each other; this situation can vary a great deal from one section of the transport market to another.

4. A great number of professional transport firms which are most of the time acting in competitive markets

In addition the number of competitive firms can be quite different per mode of transport.

5. Technological developments

Which can have great influence on certain parts of the transport market (e.g. the development of container transport).

6. Changes in social and economic thinking (environmental aspects, avoiding air and noise pollution).

An example of this is the desire to keep heavy lorries out of town centres, a possible solution being a switch to freight depots.

From this summing up it must be clear that only via systematic and methodologically reliable research it will be possible to uncover this complex structure and make it manageable for the purpose of policymaking.

1.2. Types of policymakers

It is very important to understand that there are different types of policymakers, each of them have their own needs for information. A distinction can be made between the individual transport firms, the government and the organized transport industry. The first group has by their policy actions (investment policy, pricing policy, choice of submarkets etc.) a great influence on the real course of things in the transport market.

Beside the transport firms the government has its own responsibility in creating a general transport policy based on its overall objectives which leads to a general framework in which the transport firms are functioning. It must be clear however that consultation between the government and the transport industry is necessary, because in the end the objectives of the government have to be realized by the companies.

The needs of a third policymaking body comes logically from the above mentioned consulting process. The organized industry has as its main task the protection of the joint interests of the transport industry.

1.3. Levels of management information and time-scale distinction in policymaking

To get a clear understanding of all types of management information needed, first of all a distinction has to be made between different levels of aggregation. Normally the following classification is suitable:

– macro level (concerning the transport sector as a whole c.q. per mode of transport placed in an interregional framework)

– meso level (concerning subsectors, various markets per mode of transport)

– micro level (concerning individual transport firms)

Although the macro and meso level primarily concern the field of responsibility of the government and the organized industry, it is often very important for the firm's policy and strategy too. On the other hand micro information on the firm's level is the source of the more aggregated macro and meso information on which the government's policy has to be based.

A second important aspect concerns the difference in time-scaling periods.

Normally policymaking can be distinghuished in:

a. long term policy (general outline of the objectives and instruments to be used)

b. medium term policy (gives a more concrete form of the mentioned general outline)

c. short term policy (application of policy instruments to actual situations)

Medium term policy can hardly be used to create on conjunctural deviations or incidental problems of every day. Here short term policy is needed which must be consistent with long term and medium term policy. On the short term many structures can be considered as fixed by which reason the extent of influence as well as the choice of instruments remain restricted. On the long term however it is possible to influence the underlying structures in a real way.

1.4. The interrelations between policy information flows

For a real understanding of the policy information system it is not enough to identify the different policymakers and their need for information for short term, medium term and long term decisionmaking.

Although the need for information for the three groups of policymakers differ in degree of detail, the basic data have to come for a large part from the same sources, the transport firms. Otherwise the creation of a consistent policy is not possible. The accessibility to these sources however is most of the time different for the mentioned groups of policymakers.

Consequently, after defining the policy information needed, by each of the groups it should be determined:

i) who has access to the sources of information and who is equipped for which type of information collection

ii) at what level of aggregation or in what detail the data from the various sources should be available to the government, organized industry and the firms.

Only then it is possible to have sophisticated policy information systems with reliable recent information at minimum costs, for each interested party.

The interrelationships between information patterns are given in fig. 1. In this train of thought the organized industry is, as it were, the interface between the government and the firms; it should be involved in the policymaking of each of the two groups and in particular be responsible for reconciling the interests of individual firms with the interests of the branch of industry as a whole.

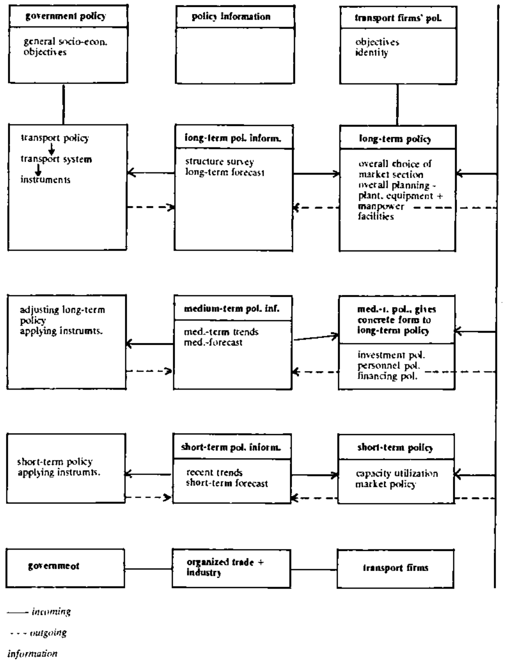

Fig. 1

Based on this philosophy the Netherlands Institute of Transport (NVI) and the Economic Bureau for Road and Water transport have developed and are still developing policy information systems for the freight transport sector (government and transport industry). In this research work there is a continuous tendency to integrate macro and micro aspects of the transport sector, whereby more and more macro-systems are joining, based on the micro-structure derived from individual firms. Given the time available only attention can be given to the policy information systems developed at the macro and meso level.

THE POLICY INFORMATION SYSTEM DEVELOPED AT MACRO AND MESO LEVEL

2.1 The basic model structure

Since the completion of an Integral Traffic and transportstudy in the Netherlands 1972, during which study the proto-type of a freight forecasting model was developed, an important amount of research has been done to improve the mentioned forecasting system.

With regard to the further improvement and development of the model already in an early stage two basic requirements were formulated. In the first place the model should be set up as a policy information system. Which means that with the aid of the system all kinds of consequences of alternative economic developments and alternative transportpolicy strategies could be quantified. Only in this way the system could function in the preparation of policymaking for the government as well for the transport industry. The second requirement which was formulated concerned the utilization of the computerprograms on the basis of the freight models developed.

The programs should be flexible enough to handle a lot of policy problems and the costs of using these programs should remain relatively low, in order to fulfil a real function in the policymaking process.

Now - 1977 - it can be said that the policy information system for freight transport, available in an operational form, is complying to a great extent with these requirements.

However before describing the basic structure of the model in a more detailed way it should be mentioned that the set-up of the model system was especially meant for freight forecasting (domestic and international transport) on medium- and long term, whereby the application for the long term is partly restricted to the condition that the environmental planning is not changed to a great extent. However the possibilities of using the model system would be underestimated if the model would only be seen in the light of forecasting the volume and composition of freight transport. As a policy information system the model forms also the base for determining the consequences of alternative transport policy strategies. The basic structure of the model developed can best be shown as a whole in figure 2. It is obvious from this diagram that the transportmodel is part of a larger system: the policy information system.

The transportmodel is fed by three categories of data, i.e.

– the general objectives
– the economic and technological variables exogeneous for the transport sector
– the instrumental variables (kind and level)

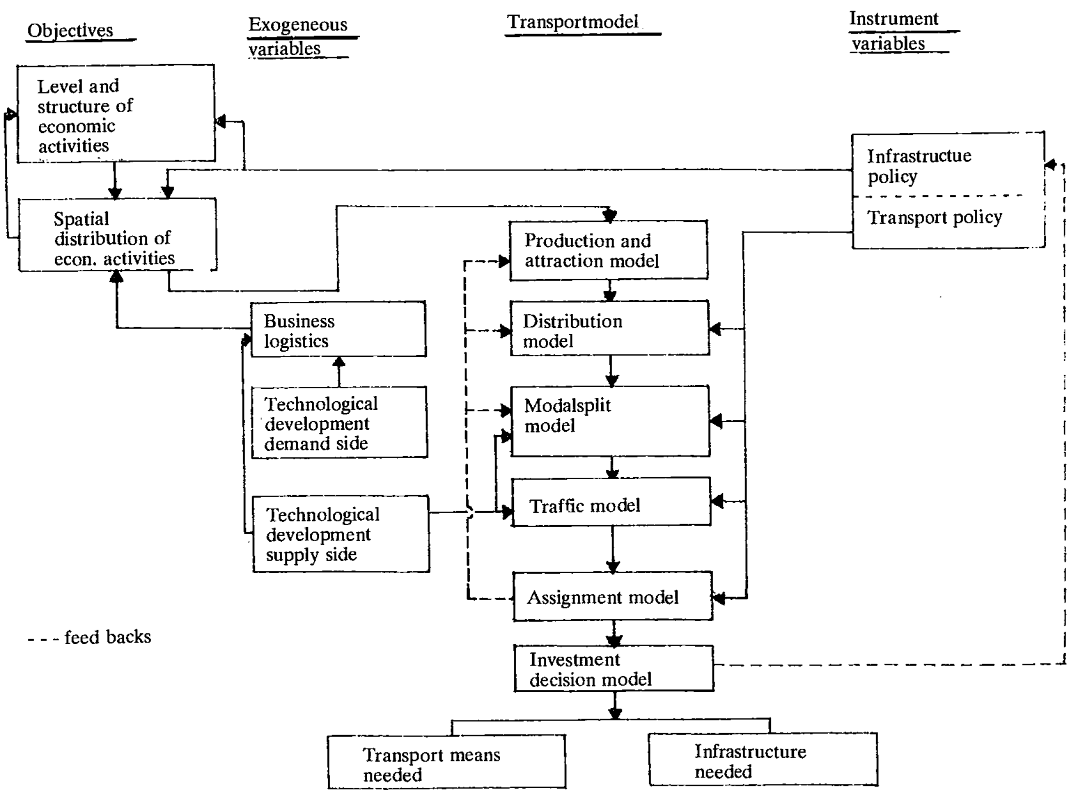

Figure 2 - The basic structure of the freight policy information system

Furthermore the feed-backs from the transportmodel to the three categories of data are explicitly shown in the diagram. It would appear that in many cases these categories of data are also in themselves the results of model systems which form an interdependent system with the transportmodel. The structure of the transportmodel (a set of submodels) in the narrow sense can best be shown in figure 3, whereby the commodity transport from, to and within the Netherlands is taken as a starting point. In the total cycle of submodels a distinction is made between two main categories: domestic transport and international transport. Domestic transport includes the commodity transport with origin and destination within the Netherlands, as well as import overseas and export overseas; international transport includes import en export via land frontiers as well as transit without transhipment. Initially the demand for freight transport is split into domestic and international transport. The most important reasons for this are:

a) the structure with the base of explanation of the two categories

b) the way in which the statistical data for commodity transport are coming available

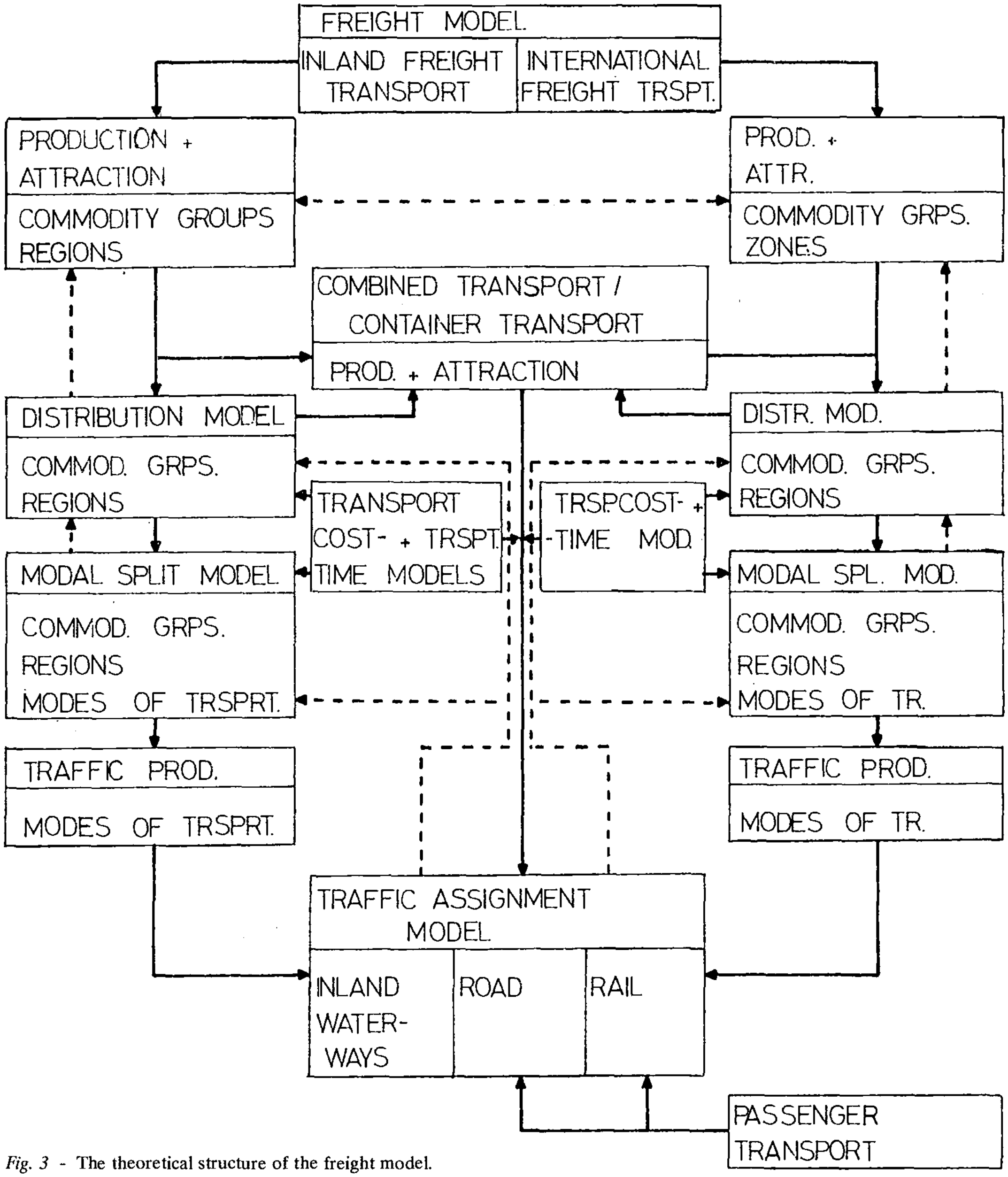

Fig. 3 - The theoretical structure of the freight model.

In view of the complexity of freight transport demand, both domestic and international transport are split into different phases. A sub-model was developed for each phase. Thus the production and attraction model determines the supply and demand per commodity group per region (number of tons); the distribution model determines the transport volume per transport relation per commodity group; the modalsplit model distributes the transport volume per commodity group per transport relation between the modes available, after which the traffic model converts the tonnages carried into both loaded and empty trips. After generation and attraction per zone have been determined the appropriate transport package for container transport is substracted or since this type of transport clearly has different transport characteristics than the remaining freight transport. The finally determined traffic production for domestic transport is assigned, together with the traffic production for international transport (both excluding container transport) and where appropriate together with the traffic production for passenger transport, to the relevant infrastructure networks.

Since after the above mentioned traffic assignment travel times and transport costs per relation may not be the same as the values initially introduced into the preceding models, there has to be a feedback from the beginning into the afore going models (from the traffic assignment model to the other submodels). By means of an iterative calculation process the ultimate equilibrium for the entire model (demand and supply) can be determined.

2.2 The possible medium and long term applications of the basic system

Before going into the possible applications of the policy information systems it may be useful to give a general indication of the ways the model results can be influenced substantially. Clearly the volume and composition of the freight transport demand is very dependent on

– the level and composition of economic activities
– the geographical spread of these activities

Changes in the economic development, both in general and in individual sectors, can exert a considerable influence on goods transport demand per transport relation. Such changes in transport demand cause changes in the transport and traffic infrastructure requirements, and in the scale and composition of the transport service offered per mode of transport, thereby causing changes in the amount and composition of the capacity needed per mode.

In addition, however, developments influencing the supply side of the transport market may cause changes in the size and composition of the goods transport package (total traffic). Technological changes in the despatch of goods, changes in the scale and the quality of the transport infrastructure available, changes in the legal regulations for the various modes of transport, changes in operating systems (e.g. the railways), changes in the amount and composition of the transport capacity available, and changes in consignment sizes etc. all affect absolute transport costs and journey times, and influence the relative transport costs and haulage times of the various modes of transport, and thereby influence the volume and composition of the freight transport pattern, as well as the distribution thereof between the transport modes available.

In other words, the model results may be influenced both by spatially differentiated economic development and the elements which independently from transport demand determine the supply of transport services.

Some examples of the potential applications of the basic freight transport model are given below:

(a) Medium- and long term goods transport forecasting

By making assumptions about economic growth (in general and for individual sectors) in the Netherlands and abroad forecasts can be made of:

(i) the volume of domestic commodity transport by commodity groups and market section

(ii) the volume of international commodity transport by commodity (15) groups and market section

(iii) the geographical split of commodity transport per commodity group over transport relations for domestic international transport (in the present model the Netherlands is split into 76 zones, but any other subdivision is possible)

(iv) the share of the transport modes (railways, roads and inland water ways) per transport relation commodity group

(v) the number of vehicle movements, both loaded and empty, per transport mode (lorry journeys, movements of shipping and wagons) per carrying capacity class and per transport relation

(vi) the traffic intensity for the different types of transport infrastructue (rail, road, water) depending on the kind and size of traffic networks brought into the model, with the possibility of a subsequent comparison of traffic intensity and capacity.

(b) Impact assessment for transport policy alternatives

In addition to making forecasts, the policy information system developed can be used to assess the impact of alternative policies in many areas of transport policy, for the statistics described in (a) above.

These alternatives may concern:

(i) measures designed to alter the conditions of competition between the transport modes (e.g. by influencing transport costs and rates)

(ii) measures designed to alter despatch arrangements (e.g. the railways)

(iii) measures designed to improve transport infrastructure and infrastructure policy (e.g. by means of transport infrastructure goods stations)

2.3 Other potential applications of the available policy information system

Other applications than those interdict as support for the preparation of policy by the government and the transport industry as described in the preceding paragraph, are possible, using extra sub-models. The principal methods is to combine the results of the basic model with specific (micro-level) information on the level of individual transport firms. In this way, policy information can be obtained as a support for the following areas of government policy and/or the policy of transport-firms.

a. Transport capacity

(i) Estimate of the future size and composition of the inland shipping fleet and the lorry fleet required to handle the freight package (total transport demand) quantitatively and qualitatively

The capacity required depends on the volume and composition of the forecast transport demand (all aspects)

(ii) a comparison of the above mentioned size and composition of the inland shipping fleet and the lorry fleet with the capacity currently available provides information about necessary extensions to, or reductions in the various components of supply.

b. Support for ratemaking

The results of the traffic assignment model can be used for the purpose or ratemaking in the inland waterway sector and the road sector; using the empty trip model allowance can be made in the tariff basis for the geographical likelihood of return freight. It is also possible to investigate the extent to which constraints on the capacity of the inland waterway infrastructure (waterways, locks, bridges, etc.) increase costs for the various types of vessel.

c. Infrastructure

The model results can form the main basis for sophisticated costbenefit analyses for decisions on transport infrastructure projects. This applies to infrastructure decisions concerning the inland waterways, road transport and rail transport as well.

d. Ports

The model results can also be used to assess the quality of the hinterland connections for the major Dutch ports.

e. Support for structure surveys

After appropriate extensions have been made, the model system can be used as the principal tool in carrying-out transport structure surveys. The above mentioned capacity estimates for the inland shipping fleet and the lorry fleet can be linked to this system.

The requisite investments can be established, and the profitability trends forecased, and so on.

f. Combined transport systems

The model results can be used to investigate in greater detail the potential marketing outlets for container transport and combined transport systems (e.g. rail/road).

g. Policy with regard to spatial integration (land-use planning)

The incorporation of long-term freight demand functions in the system available makes it possible to analyse more closely the consequences of structural changes in spatial integration policy and regional economic policy, on the one hand and in transport policy (particularly as regards infrastructure policy), on the other.

This impact assessment concerns in particular the interrelationships between the various areas of policy.

The extent to which the spatial integration of economic activities can be altered in the light of the existing financial and physical "elbow-room" in infrastructure policy, or the extent to which the spatial integration of economic activities can be altered in the desired direction with the help of infrastructure policy, are questions which can be answered using the policy information model.

h. Support for short-term policy

The distinction between time scales in policymaking has not been explicitly discussed with regard to the potential applications described so far. Clearly, this distinction adds an extra dimension to the potential applications of the policy information system.

After bringing short-, medium- and long-term demand functions into the policy information system, information relating to policy for the period concerned can be obtained in a suitable form for the abovementioned applications. In theory, the same basic model structure is used as a starting point.

As regards the use of the various sub-models, it is possible, depending on the time periods concerned, to regard certain structures described by these sub-models as constants. For the short term, this applies for example to the modal split and physical distribution systems. For the long term, the changes in all the sub-models are part of the total calculating process.

The short term system offers vast possibilities for monitoring freight trends, particularly as regards the short term aspect of transport. Short term trends in economic activity can be converted into probable freight transport market trends, the latter being reflected in the most important market indicators. For example, information concerning:

(i) the price trend of each market section
(ii) the capacity utilization of each market section
(iii) the profitability trend of each market section
(iv) equipment utilization planning and reserving of equipment (the railways)

2.4 Geographical application of the freight model system

Although the in section 2.3 mentioned models were specific developed for the Dutch situation, the basic structure of the model is, in adapted form, applicable for almost every geographical area.

At this moment a complete model system will be developed on behalf of the European Commission for the European Community (9 countries). This model will mainly be used by the Commission for the preparation of their infrastructure policy for rail, road and inland waterway shipping.

Such a policy will depend upon the long term development of variables such as population, economic growth, technical advancement etc. It will be clear that the future development of these variables (and others) will be very uncertain. In order to reduce the degree of uncertainty as much as possible the model will be set up as a sensitivity model; thus it will be possible to determine the consequences of alternative assumptions on the future development of the variables mentioned. A coherent set of assumptions on these variables is called a "scenario". The model will make forecasts of the expected traffic flows and the corresponding loadings of the infrastructure. By comparing the results of various scenarios one can ascertain the relative importance of the above variables. An additional factor to be considered is the influence of alternatives within the transport policy itself, not only as far as the market forces (taxes, etc.) are concerned, but also concerning the infrastructure. A coherent set of assumptions made here is called a "strategy".

After having decided on a certain scenario the model results for that scenario will enable to judge the merits of alternative strategies.

It should be mentioned here that a model of this type needs a great deal of data. Moreover for many variables (e.g. the traffic flows) these data need to be spatially differentiated. A preliminary survey carried out by the NVI has shown that there are in general sufficient data available in the different countries. The first stage of the actual project - that started at the end of 1975 - consists of collecting, screening and ordening the data available. It will be noted that the reliability and the degree of detail of the model that will eventually be constructed will depend upon the quality of the data provided by the various countries.

In the ultimate set up of the freight model system a distinction will be made between domestic models (as far as possible one model for every country) and an international model with which the commodity and traffic flows between the regions of the different countries are forecasted. Although the first idea was to develop only an international model, statistical data showed that only 5% of the total commodity transport volume should be covered by this model. To get a right insight in the traffic intensities, caused by commodity transport, of the different infrastructure networks made it necessary to incorporate the domestic transport too (83% of the total transport volumes). To give an idea about the dimensions of the freight model systems in development the following can be mentioned:

The model system will deal with:

- three detailed European infrastructure networks
  - road
  - rail
  - inland waterway
- fourteen commodity groups
- a large number of regions
  - for international transport the 70 so called E.C. transport regions will be used
  - for domestic transport the number of regions vary with the geographical size of the countries concerned

To give a few examples:

Germany - 79 regions
United Kingdom - 134 regions
France - 95 regions
Netherlands - 13 regions

At this moment the project is in the data collection phase. Statistical data on commodity transport per geographical relation are collected to fill the different origin and destination tables. At the same time socio-economic data are collected for the different countries and their regions to form the basis for development of the different production and attraction models. Infrastructure network data (level of service variables), transport cost data etc. are collected for the development of transportation cost models which are necessary to develop the distribution and modalsplit models.

The model development itself will start in the second half of this year and will probably be finished in one year. The model development will not only take place for the E.C.-area, some ECMT-countries like Spain will be integrated in the same model system too.

A second example of geographical application of the models can be mentioned for the case of Switzerland. On behalf of the National Committee responsible for the general transportation plan of Switzerland a large part of the described freight system has been developed as a part of an integral transport and traffic model. A very interesting point here is the integration of commodity transport models and passenger transport models. In a simultaneous assignment procedure the traffic flows caused by commodity transport and passenger transport are assigned to different infrastructure networks. This gives the possibility to get a clear picture of the total traffic intensity and their interdependencies on the networks. Via feedback calculations the ultimate equilibrium can be established.

A last example concerns some Federal Republics of Yugoslavia. Also for these areas it is intended to develop the same kinds of freight transport models, of course after the necessary adaption to the local situation.

The conclusion which can be drawn from all these applications is that the theoretical model structure can be maintained for different social, economic and political situations. In most cases the number of necessary local data can be reduced to the minimum, because a lot of extra data can be produced by analog methods (for example cost functions).