FORWARD: Freight Options for Road, Water, And Rail for the Dutch

Project Overview

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This overview briefly describes the results of a research study that was performed for the Netherlands Ministry of Transport, Public Works and Water Management by the European-American Center for Policy Analysis (EAC), which is a part of RAND. The study, called Freight Options for Road, Water, And Rail for the Dutch (FORWARD), examined the benefits and costs of various changes to the Dutch system of freight transportation. It developed strategies for mitigating the negative impacts of the expected growth in freight transportation on roads while retaining the economic benefits.

A detailed description of the approach and results will eventually appear in the project’s final report, which will be published later in 1995. The conclusions should be of direct interest to freight transport policymakers, and the methodology should be of interest to transport system analysts.

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SUMMARY

The Freight Options for Road, Water, And Rail for the Dutch (FORWARD) project is a policy analysis study that was carried out by the European-American Center for Policy Analysis, which is part of the RAND Corporation, in cooperation with the School of Systems Engineering, Policy Analysis and Management of Delft University of Technology, on behalf of the Ministry of Transport, Public Works and Water Management. This study examined possible ways to mitigate the negative impacts of the projected increase in freight transportation on the Netherlands' highways, while attempting to retain the economic benefits from the efficient and reliable transport of goods. On an aggregate level, the study gives insight into the impacts of a large number of tactics (and combinations of tactics), which are single actions taken to affect the freight transportation system. The various tactics fall into three main categories: direct mitigation of negative effects, more efficient freight movement by road, and inducing a modal shift to alternative modes, such as railways and inland waterways. To assess the impacts of the possible changes in the transportation system, a microcomputer-based policy analysis model called Policy Analytic Computational Environment for FORWARD (PACE-FORWARD) was developed. The user can directly interact with the model to gain insights into the effects of the various tactics on emissions, noise, safety, congestion, costs, and the national economy. PACE-FORWARD is an integrative model that is comprised of modules that use data, factors, and relationships from existing Dutch transportation models and databases. Results on tactic performance produced by PACE-FORWARD were used to design combinations of tactics (called strategies) that might contribute to achieving a range of national goals. In particular we found that efficiency tactics were the most promising, that selected direct mitigation measures could be used to "fill in" for gaps in goal achievement, and that mode shift tactics were generally not cost-effective and were relatively ineffective at changing impacts.
1. INTRODUCTION

The Freight Options for Road, Water, And Rail for the Dutch (FORWARD) project is a policy analysis study focused on ways of coping with the projected massive growth in road freight transportation in the Netherlands. The primary purpose of this multidisciplinary study was to examine possible ways to mitigate the negative impacts of increasing freight transportation on the Netherlands' highways, while also attempting to retain its economic benefits.

Begun in December 1992, the project was carried out by the European-American Center for Policy Analysis (EAC) of the California-based RAND Corporation, for the Netherlands Ministry of Transport, Public Works and Water Management (hereafter, the Ministry). The project team was composed of researchers from the EAC, RAND, and the School of Systems Engineering, Policy Analysis and Management of Delft University of Technology. With the support and active participation of staff members of the Ministry, a set of policy analysis tools was designed and built to assess the impacts of various policy alternatives and identify the most promising options.

In the following sections, the project is described in more detail. Section 2 defines the project in terms of its goals, scope, and approach. Section 3 outlines the policy analysis approach, and Section 4 provides more insight into the PACE-FORWARD model. Section 5 shows how promising combinations of policy options were designed. Detailed results from the FORWARD project will be published in the project's final report, but some general insights and conclusions are given in Section 6. Further research possibilities are outlined in the paper's final section.
2. THE FORWARD PROJECT

2.1 PROJECT GOAL

The Dutch government's Second Transport Structure Plan (SVV) says: "the movement of goods by road is growing even faster than that of people. Unless rapid and effective steps are taken to encourage the transport of freight by rail and waterway and enhance the efficiency of road transport, the volume of truck traffic ... will grow by 100% (by the year 2010)" [Second Chamber of the States-General, 1990]. Such an increase in road traffic is likely to lead to significant increases in congestion and pollution, and to other disbenefits to society. The FORWARD project examined the question of whether there are ways of obtaining the economic benefits from this increase in freight transportation without incurring as many of the disbenefits. On an aggregate level, the FORWARD project provides insights into a wide range of impacts of various policy options. To evaluate the options, three future (year 2015) economic scenarios, developed by the Dutch Central Planning Bureau (CPB), were used: "Global Shift" (little economic growth), "European Renaissance" (moderate economic growth), and "Balanced Growth" (significant economic growth). For comparison purposes, the situation in the year 1990 was used as a baseline. (The year 1990 was the most recent year for which a complete set of highway statistics and impacts was available at the time of the study.)

2.2 RESEARCH SCOPE

The FORWARD study was a broad study that integrated current knowledge in the field of freight transportation. The project examined many tactics, which are single policy actions taken to affect the freight transportation system, as well as combinations of tactics, which we called strategies. It assessed the impacts of the various tactics and strategies on a range of performance measures, as depicted in Fig. 1.

An early task in the project was to generate a large number of tactics. In order to get as many tactics as possible, several brainstorming sessions were arranged. The project group held two internal brainstorming sessions at the Ministry, and also met with representatives from shippers, the transport industry, truck manufacturers, consulting firms, and other ministries. In all, a list of almost 200 freight tactics was compiled. These can be divided into three main categories:
1. Direct Mitigation Tactics
These tactics are addressed specifically to reducing one or more of the negative impacts at their source. Most of them are technical improvements to trucks to reduce the emissions and noise nuisance of trucks, as well as to increase the safety on highways. Examples are the use of soot filters, or the reduction of the power/weight ratio of trucks. Tactics that change the road infrastructure in order to reduce congestion are also included in this category.

2. Transport Efficiency Tactics
These tactics seek to use the existing truck fleet and transportation infrastructure more efficiently. Examples of efficiency tactics include the use of City Distribution Centers and fuel-efficient trucks.

3. Modal Shift Tactics
These tactics are designed to shift freight off the roads and onto other modes of transport. They include various ways to make rail and waterway transport of freight more attractive by making these modes faster and more reliable. They also include ways to improve transshipment capabilities, and ways to provide regulatory or price incentives for modal shift. Besides shifting freight to rail and waterways, the project considered possibilities for transportation of freight by alternative modes such as moving sidewalks for containers, short sea transport, and pipelines.

![Diagram](Image)

**Figure 1—Elements of the FORWARD Study**

The performance measures that were considered in the FORWARD study can be divided into six categories:
1. Emissions
   The impacts of the tactics on six types of emissions (CO$_2$, NO$_x$, CO, SO$_2$, C$_x$H$_y$, and aerosols) were estimated. The emission estimates were produced for each mode—road, rail, and waterway.

2. Noise
   The effects of the various tactics on the noise nuisance caused by freight transportation on the Netherlands’ highways was estimated. The noise impact measure used is the average distance from the highways to the 50dB contour. Since the noise impacts of transporting freight by rail and/or inland shipping have a completely different character, these were not considered in this study, nor was the noise produced by urban truck transport.

3. Safety
   Various safety impacts of the tactics were measured including the number of accidents, injuries, and fatalities caused by freight-related transport by road, rail, and/or waterway. The number of accidents related to the transportation of hazardous goods was also estimated.

4. Congestion
   The total congestion severity (number of incidents * average length of tailback * average duration of incident) was taken as a measure of congestion on the Netherlands' highways.

5. Costs
   Within the FORWARD study, the net societal cost of a tactic was estimated. This represents the total costs and savings of a tactic regardless of who pays. This takes into account the fact that there may be a cost transfer from one stakeholder to another, but avoids the problem of exactly how such a transfer would be implemented. The total cost of a tactic was split into four parts: delay costs (the cost of freight waiting for pickup or being transshipped), investment costs, operating costs, and maintenance costs. The value of time plays a major role in the determination of the total costs.

6. Economy
   For the economic impact of the tactics, the changes in employment and value added for the transport sector as well as for the production sector were estimated. The effect on the Dutch market share in transporting freight between the Netherlands and other European countries was studied as well.
2.3 POLICY ANALYSIS MODEL

Given a specification of the transportation system, the impacts of various tactics can be estimated with analytical techniques. As part of the FORWARD project, an assessment was made of existing Dutch freight transportation system models to determine if any had the capabilities needed to estimate the impacts of the tactics to be evaluated. The assessment criteria involved the scope and level of detail of the models, their operational performance, their demand databases, and opinions from the FORWARD project's Steering Group. It turned out that no single model or combination of models had the required capabilities. As a result the FORWARD project team developed a microcomputer-based policy analysis model that integrated aspects of the various Dutch models. In this model, the major modes of inland freight transportation are included—roads, inland shipping, and rail. The model calculates the impacts described above. It is compromised of a number of modules, some of which use equations and data from existing models and some of which entailed the creation of new equations and the compilation of new data.
3. THE POLICY ANALYSIS APPROACH

The FORWARD study used a systematic approach to examining complex public policy choices called policy analysis. Policy analysis is not a single method or a technique, or even a fixed set of techniques. Rather, it is a process that includes the use of models and advanced analytical techniques appropriate to the issues being addressed. Its purpose is to assist policymakers in choosing preferred courses of action from among complex alternatives under uncertain conditions.

In this definition, the word assist emphasizes that, in determining public policies there is rarely a "best" solution. No alternative is likely to have all of the most favorable consequences. Different alternatives will do better on some consequences and worse on others. Policy analysis aids policymakers to exercise their judgment by clarifying the problem, outlining the alternatives, and displaying tradeoffs among their consequences. The word complex emphasizes that the alternatives are often numerous, involve mixtures of different technologies and management policies, and produce multiple consequences that are often difficult to anticipate. The word uncertain emphasizes that the choices must generally be made on the basis of incomplete knowledge about alternatives that may not yet physically exist and whose predicted consequences will occur—if at all—only in an unknown future.

The elementary building blocks of a policy are called tactics. In the FORWARD project, tactics were single actions taken to affect the freight transportation system—e.g., requiring a fixed percentage of new trucks sold to use quieter engines. A strategy is a combination of tactics designed to achieve a particular goal. For example, using a soot filter on trucks in combination with a low sulphur diesel fuel and a more efficient way of driving by the truck drivers, is aimed at reducing emissions from trucks. A policy is a combination of strategies, which might contain any number of tactics.

In a policy situation as complex as that dealing with freight transportation in Europe, it is easy to become overwhelmed by the "curse of dimensionality." That is, there are so many possible alternatives, so many uncertainties, and so many consequences of interest, that no analysis can consider all of them. To deal with the curse of dimensionality, the analysis is performed in a series of stages (see Fig. 2).
The first step in performing a policy analysis is to (re-)formulate the problem. This is done in close cooperation with the policymakers. The next step is to specify the criteria with respect to which the performances of the possible solutions is to be measured. Also, a comprehensive list of tactics that address the problem is developed. These tactics are then screened in terms of a few of the major criteria to make a rough distinction between promising and non-promising tactics. The purpose of this step is to come up with a relatively small number of promising tactics to be evaluated in terms of a large number of impacts. The next step is to formulate promising strategies—that is, promising combinations of tactics. Such strategies do not necessarily have to be a combination of the most promising tactics. It could be that less promising tactics in combination with other tactics may form good strategies. The combined impacts of strategies are usually not simply the sum of the impacts of the individual tactics, but a more complex interaction. Thus, the strategies must also be analyzed in terms of their consequences to finally develop promising strategies. The choice among the different strategies is left to the policymakers. Policy analysis thus assists the policymakers in choosing preferred courses of action by providing the relevant information in a structured way. For a more detailed description of the policy analysis approach see Goeller, et al. [1983, pp. 34-39] and Patton and Sawicky [1986, pp. 17-39].
Figure 2—The Stages of Policy Analysis
4. PACE-FORWARD MODEL

4.1 CHARACTERISTICS

The tool that was used to assess the impacts of the various tactics on the performance measures of interest is the Excel spreadsheet PACE-FORWARD model. PACE stands for Policy Analytic Computational Environment. The model estimates the various impacts of specific tactics on an aggregate basis. The user interacts directly with the model, which is PC-based and menu driven, to gain insight into the effects of possible changes in the transportation system.

The model allows the user to choose one of the modeled tactics and one of the scenarios: the current situation (1990) or one of the future scenarios of the CPB (for the year 2015). It then calculates the impacts related to air pollution, noise pollution, safety, congestion, costs, and the national economy. The user chooses the impacts to be displayed. The results are given in absolute numbers and in percentage changes. Alternative formats for displaying the results include maps, graphs, and scorecards. A scorecard is a matrix in which the rows represent impacts and the columns represent tactics. A column shows all the impacts of one tactic, while a row shows the impacts of all the tactics on one specific performance measure (see Fig. 3).

<table>
<thead>
<tr>
<th>Performance measures</th>
<th>Tactics -&gt;</th>
<th>Build City Distribution Centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 Emissions</td>
<td>Use cleaner diesel engines</td>
<td>...</td>
</tr>
<tr>
<td>Noise</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Injuries</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Congestion</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Net societal cost</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Employment</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Figure 3—Sample Scorecard

The PACE-FORWARD model provides the user with a way to quickly obtain information about the estimated performance of tactics as part of the process of formulating a policy. The way policymakers use this information, and the final choice and selection of preferred policy options is, of course, up to them.
4.2 MODULES

Although time and money are always limiting factors, each of the tactics was analyzed in as much detail as possible. To model the tactics, equations and data from existing Dutch models and studies were used as a basis in PACE-FORWARD to compute the various impacts related to air pollution, noise, safety, congestion, costs, and the national economy (see Fig. 4). Although the impact modules come from different sources the architecture provides a structure within which they function together, using consistent assumptions and a common database.

![Diagram of PACE-FORWARD modules](image)

**Figure 4—Impact Modules of PACE-FORWARD**

For the development of the emission module, models from NEI (The Netherlands Economic Institute) and TNO (Netherlands Organization for Applied Scientific Research) were used. To compute the highway safety impact of the tactics, a module was developed based on data from the SWOV (Institute for Scientific Research on Traffic Safety), the Central Bureau of Statistics, the Ministry of Transport, Public Works and Water Management, and several discussions with safety experts at Delft University of Technology and the Netherlands Transport Research Centre (AVV). The noise module is based on the information given in Article 102 of the Dutch noise nuisance law. The economy module was developed in cooperation with NEI.
4.3 STRUCTURE OF PACE-FORWARD

The PACE-FORWARD model is supported by a large database, which includes freight transport demands for the current (1990) transport situation, as well as for the three CPB demand scenarios (for the year 2015). The demand data are given in terms of tonnes and tonne-kilometers to be transported between a given set of origins and destinations. For each scenario, the fleet characteristics (trucks, trains, and ships) as well as the networks of the three modes (road, rail, and inland waterways) are also part of the database. Baseline data for the impact modules related to emission, noise, safety, congestion, costs, and the economy are stored in the database as well.

Some tactics change the supply side of the transport system (e.g., building new infrastructure); some directly influence the mode choice (e.g., increasing the tax on diesel fuel); some change specific parameters of one or more impact modules (e.g., building cleaner diesel engines). After the user has chosen a tactic and a scenario, the model calculates the different impacts. First, the model translates the changes in the supply side of the transport system into changes in mode choice, after which the number of vehicle kilometers for each mode is calculated. Given this information, the effects on emission, noise, safety, congestion, costs, and the economy are estimated. The different impact modules are not completely independent of each other (see Fig. 5). For example, the congestion calculations are closely related to the emission, noise, and safety computations. Furthermore, the cost module is one of the inputs to the economy module.

4.4 TACTIC IMPACT ASSESSMENT

Figure 6 shows the user interface of PACE-FORWARD and gives an example of a graphical display of the results generated by the model. The tactic and scenario being examined are displayed on the screen, as is the date of the run. The vehicle types, fuel, and commodity types related to this tactic are indicated as well. Input data defining the tactic in terms of its effect on the number of loaded trips, truck utilization factor ('Loading'), fuel use, emissions, etc., are given in terms of indices. The user can make changes to these factors to modify the tactic or implement it selectively. In this way, the policymaker may choose, for example, to use speed limiters only on heavy trucks.

Figure 6 displays upper bounds on the emission effects from implementing a tactic in which road transporters use telematics to identify loads to be transported and, therefore, increase their truck utilization factors. We made optimistic assumptions about the effects of tactics, so that we would not screen out any tactic that might be promising. In this case, we assumed that trucks would increase their average utilization factors to those identified as
upper bounds in the Dutch Trendbreuk study [Werkgroep 'Zduizend, 1993]. Increased utilization factors lead to fewer truck trips, and, thus, fewer trucks on the road. As a result, the model estimates that emissions from road freight would be reduced significantly (see Fig. 6), injuries and fatalities from truck accidents would be reduced to below their 1990 levels, and noise and congestion would also be reduced. The tactic would result in some extra delay costs for the goods being transported, because they will have to wait somewhat longer to be picked up. There will also be small investment costs. But these costs will be more than offset by the cost savings from having fewer truck trips (and, therefore, fewer vehicle kilometers driven). As a result, our assessment of this tactic found it to be very promising.
Figure 6—User Interface and Sample Display from PACE-FORWARD

The figure above shows upper bounds on the estimated reduction of six types of emissions (NOx, CO, CO2, SO2, hydrocarbons, and aerosols) from implementing the tactic “use telematics by transporters” compared to the 2015 European Renaissance situation without the tactic implemented. The reductions for each type of pollutant are shown in several ways:

- percentage reduction in emissions caused by road freight transportation
- percentage reduction in emissions caused by road freight transportation relative to the emissions caused by all freight transportation
- percentage reduction in emissions caused by waterway freight transportation relative to the emissions caused by all freight transportation
- percentage reduction in emissions caused by rail freight transportation relative to the emissions caused by all freight transportation
- percentage reduction in emissions caused by all freight transportation
- percentage reduction in emissions caused by all road traffic (passengers and freight)
- percentage reduction in emissions caused by all human activities
5. STRATEGY DESIGN

Developing promising combinations of tactics (i.e., strategy design) is a complicated process. First, the project evaluated about 70 individual tactics using PACE-FORWARD, yielding many feasible combinations of tactics to be examined, and each tactic will generally affect many of the impact measures. Second, the impacts of a strategy are not the sum of the impacts of the constituent tactics. Related tactics interact with each other in nonlinear ways. Third, there is no consensus on what constitutes a good strategy—i.e., what weights should be given to the various impacts. Different weighting schemes are likely to lead to different strategies.

The approach taken on the FORWARD project was to build a model called the Cost-Effectiveness Model (CEM), and to use it to generate tactic rankings for a given set of weights. The CEM is, like the PACE-FORWARD model, an Excel spreadsheet model. One of its inputs is a tactic scorecard, whose columns are tactics and whose rows are the estimated impacts produced by PACE-FORWARD (see Fig. 7). Its other major input is a set of weights to be applied to the impact measures. It is also possible to exclude selected tactics to create a ranking of subsets of tactics (to examine, for example, the ranking of mode shift tactics only).

![Figure 7—Use of Models in the FORWARD Project](image-url)
The CEM first calculates the "effectiveness" (E) of a tactic, where effectiveness is defined to be the sum over all impact measures of the product of the impact measures and their associated weights. That is, \( E = \sum w_i m_i \), where \( w_i \) is the weight assigned to impact measure \( i \), and \( m_i \) is the value of impact measure \( i \). It then divides the total annualized cost of the tactic (C) by its effectiveness to produce an estimate of its cost-effectiveness (C/E). All the tactics being considered are then ranked (inversely) by their cost-effectiveness. If there are \( N \) tactics in the tactic scorecard, this produces a list of the \( N \) tactics in reverse order of the value of \( C/E \). The CEM then calculates the cumulative values of the various impact measures assuming that the first \( n \) tactics on the ranked list were implemented together (where \( n \) can range from 1 to \( N \)). In making this calculation, it takes into account some of the interactions among the tactics (i.e., if two tactics are implemented, the resulting impact is not the sum of the individual impacts). Thus, the CEM is a tool that can be used to identify promising strategies (e.g., the first five tactics on the list that are sensible to implement together).

The model will accept any specification of weights. The choice of weights is an important decision. There is no "correct" set of weights—policymakers might choose one set and an environmentally concerned group might choose a very different set. It could create difficult choices for policymakers if the top rankings were quite different for different sets of weights (as is often the case in public policy decisionmaking). If so, it would be difficult for policymakers to create policies that were satisfactory to all parties of interest. However, in the case of the tactics examined in the FORWARD project, the results are fortunately quite robust (i.e., the most cost-effective strategies change little as the weights on impacts change). For different sets of weights, some specific tactics change their locations in the ranked list. But there are some broad insights and conclusions about types of tactics and their cost-effectiveness that do not change as weights change. Selected results for three sets of weights will be described below, and some insights and conclusions will be drawn from them.

In two meetings, a total of 13 stakeholders (representatives of organizations that would be directly affected by changes in freight transport policy) provided the project with their relative preferences among the performance measures. The average weights derived from these preferences were used as one of the sets of weights for which the ranking of the various tactics was calculated.

One of the outputs from the CEM (in addition to the list of tactics ranked by cost-effectiveness) is a graph showing cumulative costs and cumulative impacts as a function of the number of tactics included in a strategy. Figure 8 presents results from running the CEM for the average weights supplied by the above stakeholders. This figure shows eight graphs superimposed. The horizontal axis shows the number of tactics from the ranked list that are included in the strategy. (In the example shown here, we ran the model for 65 separate tactics.)
So, the ranked list includes 65 tactics. The -o- line graph is an upper bound estimate of the cumulative reduction in CO2 emissions from road freight from a 2015 base case that assumes none of the tactics is implemented. The reduction increases as the number of tactics included in the strategy is increased. (For example, in Fig. 8, the reduction increases from just over 40 percent with one tactic in the strategy to nearly 100 percent with all 65 tactics included.) The -π- line graph is an estimate of the cumulative annualized cost of implementing the tactics. Some tactics actually save money, so the cost curve starts out negative. Other curves shown on the same graph include upper bound estimates of the cumulative percentage reduction in truck-related emissions of NOx, aerosols, CO2, injuries, noise, congestion, and value added (economy). The reductions are given relative to a European Renaissance 2015 reference case in which none of the tactics is implemented.

Figure 8 also shows that implementing the ten most cost-effective tactics using stakeholders’ weights will save at most an estimated Dfl 25 billion per year and will reduce estimated 2015 emissions of CO2 from road freight by at most about 90 percent (as already mentioned, in order to avoid screening out possibly promising tactics, we used optimistic assumptions about their benefits). It will also reduce injuries involving trucks by at most 90% and will have little impact on the economy.

Figure 8—Cost-Effectiveness Model Results Using Stakeholders’ Weights
To produce a strategy that is focused on reducing CO2 emissions, a weight of 1 was assigned to the changes in CO2 emissions produced by a tactic, and a weight of 0 was assigned to the other impact measures. Figure 9 presents results from this CEM run for the seventeen most cost-effective tactics. The legend for the graph on the left is the same as in Fig. 8. The seventeen most cost-effective tactics are listed on the right side of the figure. Note that these tactics have a great effect on CO2 emissions, congestion, and injuries. But, although some tactics on the list save money, others cost money, and some have important negative impacts on value added and transportation sector employment.

Figure 9—A Cost-Effective CO2 Reduction Strategy

A third sample strategy focuses on mode shift. Only those tactics that attempt to achieve mode shift and that were shown by the CEM to be cost-effective from a net societal cost perspective are included. The strategy contains only four tactics. (The tactic “Free rail transport [for freight]” is included, since the government subsidy for making rail free is offset by cost savings to the transporters. If the cost of the tactic were the subsidy, and the transporters’ savings were not considered, this tactic would look less promising.) Figure 10 presents the CEM results for this strategy. The legend for the graph on the left is the same as in Fig. 8. The four cost-effective tactics are listed on the right side of the figure. Despite being cost-effective and costing little, these tactics do not accomplish much in terms of reducing the negative impacts from freight transport. In general, as we will state in the conclusions, mode shift tactics for either rail or waterway are either not very effective or not very cost-effective.
Figure 10—A Cost-Effective Modal Shift Strategy
6. CONCLUSIONS

Detailed results from the FORWARD project will be published in the project’s final report. However, there are some general insights reached as a result of all the research on the project, and some important conclusions based on the development of freight strategies that are summarized below.

6.1 THE MOST IMPORTANT TACTICS FOCUS ON EFFICIENCY IMPROVEMENTS

Efficiency tactics are disproportionately represented at the top of all lists of cost-effective tactics. They improve many impact measures (reducing the amount of truck movement affects all impact measures, savings in fuel economy reduces all emissions, etc.), and by their nature they tend to save money because of the efficiencies. In fact, 10 of the first 13 tactics in the list of cost-effective tactics in Fig. 8 are efficiency tactics, and all lead to a reduction in the overall cost of freight transport. (Two examples of such tactics are “use telematics in road transport” and “reward truck drivers for more fuel-efficient driving behavior”.)

These efficiency tactics provide a robust set over a broad range of weights. A comparison of the list of top-ranked tactics for stakeholders’ weights with those produced by other weighting sets (for example, emphasizing CO2 reduction) shows that the efficiency tactics appear on all lists, although they are not necessarily the same ones on all lists.

There are some other reasons why efficiency tactics tend to be important in most strategies. Most of the top-ranked efficiency tactics actually save money, at least in terms of total societal cost. While many do not make dramatic improvements, combinations of them build up to cost-effective strategies. And, since many of the efficiency tactics represent behavioral changes or regulatory changes and do not rely on future technological developments, they can be implemented in the near term. Furthermore, these tactics call for the involvement of many stakeholders, so the burden of implementation does not fall on a single agency or group.

6.2 CERTAIN DIRECT MITIGATION TACTICS ARE COST-EFFECTIVE AND ARE COMPLEMENTARY TO EFFICIENCY IMPROVEMENTS

Some direct mitigation tactics aimed at particular impacts are cost-effective and either produce net reductions in the overall cost of freight transport, or small increases. (Two examples of such tactics are “use quieter tires” and “use electric vans in urban areas.”) These tactics, although sometimes showing dramatic improvements for the measures on which they focus, generally rank lower in cost-effectiveness than the efficiency tactics because of their higher costs. The importance of these tactics is that they can ‘fill in’ for gaps in improvement not provided by the efficiency tactics by focusing on particular impacts.
However, because these tactics focus on particular negative impacts, whether they are promising or not depends to a great extent on the importance weighting of the impact measures. For example, someone who cares only about NOx emissions would favor the clean engine tactic, while someone who cares only about CO2 emissions would not. Furthermore, direct mitigation tactics tend to cost more than the efficiency tactics. But the costs might be able to be managed by targeting the largest contributors to an impact. For example, they could be selectively implemented to target urban vehicles, international (or national) trucking, and even selectively implemented in certain regions for haulers of specific commodities. In addition, most of these tactics would be implemented in the mid to long term, since they generally require some technical and/or regulatory change. This would make the cost impacts easier to bear, but would also mean that their benefits would only be realized gradually.

6.3 Mode Shift Tactics Are Either Not Cost-Effective or Make Little Difference

Our analysis has shown that mode shift tactics tend to be either cost-effective with very small effectiveness improvements, or not to be cost-effective. Waterway and rail improvements are relatively expensive and do not realize very much mode shift for a number of reasons. First, there is only limited opportunity for mode shift. The average distance traveled in the Netherlands is less than 50 kilometers, so it is unlikely that rail or waterway transport, which usually also require pre- and after-road transport and transshipment, will be attractive to forwarders for national goods movement. Second, the quantity of international trucking is much smaller than the quantity of national trucking, whether measured in terms of tonnes or tonne-kilometers. Thus, the quantity of road haulage that can be affected by mode shift tactics tends to be smaller than that affected by other tactics.

A qualification, however, is that improving service characteristics of rail and waterway transport could make mode shift more promising.

6.4 Freight Cannot Do It All

Changes to the freight transport system have only a limited ability to reduce the negative effects of road transport on such things as the environment, congestion, and noise. Only about 15 percent of all the vehicle kilometers driven in the Netherlands are driven by trucks. So, freight causes only a part, and in many cases only a small part, of the impacts relative to passenger transport. And, some tactics, such as mode shift, may be more effective for passenger transport than for freight.
6.5 THE ECONOMIC EFFECTS OF MOST OF THE PROMISING TACTICS ARE SMALL

The macroeconomic module of PACE-FORWARD shows the effects of the freight tactics on national added value and employment in the production and transportation sector. Almost all of the promising tactics show only small macroeconomic effects.

6.6 REDUCING THE NEGATIVE IMPACTS OF ROAD TRANSPORT IS EVERYONE'S BUSINESS.

An important characteristic of the promising set of tactics is that it shows that reducing the negative impacts of road transport is everyone's business, not just that of the government, and not just that of the truckers. Businesses, railways, inland shipping, and passengers must all do their part. For example, rail and waterway transporters must improve their service characteristics, and businesses must accommodate some changes in transport policy to reduce environmental impacts.

6.7 THE TACTICS IN THIS STUDY CAN NOW BE COMPARED IN A COMMON FRAMEWORK

One of the most important contributions of the FORWARD project is that enables many of the freight transport tactics being discussed in the Netherlands to be compared on quantitative and logical grounds. The FORWARD results show which tactics are the most effective on various measures and the conditions and assumptions under which they are important.

The project has also shown that many tactics do not appear to be effective or cost-effective. These results can be used to limit the focus of future deliberations to the most important tactics and strategies.

The study of any individual tactic or impact could go deeper, and some of the tactics will change their ranking in various strategies as implementation aspects are considered. However, we believe that the above set of conclusions will hold up to such continued study and that the overall approach outlined here to reducing freight impacts while retaining economic benefits will continue to be valid.
7. A GLANCE AT THE FUTURE

The FORWARD project made major strides toward enabling a broad range of policy options to be compared on quantitative and logical grounds. However, there are still a number of things that need to be understood better.

This study focused on freight, but there are substantial interfaces with passenger transport in the use of infrastructure and in terms of impacts. It would be desirable to study these interfaces in the future by expanding PACE-FORWARD and developing an integrated set of tactics for freight and passenger transport.

This project was a study of freight transport in the Netherlands. We did not consider the international movement of freight beyond the Dutch borders, except in terms of destination and distance traveled. Many tactics would have to be implemented in the European Union (EU) rather than solely in the Netherlands, so a broader EU-based study of freight (and passenger) transport similar to this study would be useful.

The development of the PACE-FORWARD model and the analysis of the tactics is mainly based on current knowledge and existing models in the field of freight transportation. New and/or better knowledge could be integrated in the PACE-FORWARD model relatively easily to update the different modules and to examine (new) tactics. For example, an elasticity module for mode choice is part of PACE-FORWARD. But this module may not predict mode shifts correctly if service improvements in rail and inland waterways are made. It is desirable to update this module using a better understanding of likely future changes in service provided by these modes.

Finally, the implementation aspects of the tactics have not been considered in this study, particularly in terms of dealing with costs and cost transfers. These and other implementation considerations must be studied as the government prepares its overall strategy toward reducing the negative impacts of road freight transport.
REFERENCES


SESO, *De Nederlandse Goederenvervoermodellen; definitief eindrapport*, University of Antwerp, Antwerp, 1991.


