Policy Analysis: A Systematic Approach to Supporting Policymaking in the Public Sector

WARREN E. WALKER\textsuperscript{a,b,*}
\textsuperscript{a} RAND Europe, Leiden, Netherlands
\textsuperscript{b} Delft University of Technology, Delft, Netherlands

ABSTRACT
This paper describes a systematic process for examining complex public policy choices that has been developed and refined over the past 50 years and is often called policy analysis. Its purpose is to assist policymakers in choosing preferred courses of action by clarifying the problem, outlining the alternative solutions and displaying tradeoffs among their consequences. In most real-world policy situations there are many possible alternatives, many uncertainties, many stakeholders and many consequences of interest. Also, there is usually no single decisionmaker and little chance of obtaining agreement on a single set of preferences among the consequences. As a result, there is no way to identify an optimal solution. Instead, policy analysis uses a variety of tools to develop relevant information and present it to the parties involved in the policymaking process in a manner that helps them come to a decision. It is a problem-oriented approach that does not presume a model structure for assessing the consequences of a policy or ranking the alternatives. The paper provides a brief history of policy analysis, describes the most important elements of the policy analysis process, provides an illustrative example of the use of the approach and suggests directions for future developments that can enrich the approach and increase the chances for successful use of the results. Copyright © 2000 John Wiley & Sons, Ltd.

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1. THE POLICYMAKING PROBLEM
The world is undergoing rapid changes. The future is uncertain. Policymakers are faced with policy alternatives that are often numerous, diverse and produce multiple consequences that are far-reaching yet difficult to anticipate (let alone predict). Different groups perceive and value different consequences differently. Nevertheless, public policymakers have a responsibility to develop and implement policies that have the best chance of contributing to the health, safety and well-being of their constituencies.

Given this context, policymaking is not easy. Uncertainties abound. Data are limited. Simply identifying the key policy issues is a difficult task and one does not have the luxury of ignoring certain topics because they are too messy or intractable. However, without analysis, important policy choices are based on hunches and guesses — sometimes with regrettable results. Over the past 50 years, policy analysts in the United States and Europe have developed a systems-based approach and a set of tools for examining public policy issues that illuminate the uncertainties and their implications for policymaking, that identify tradeoffs among the alternative policies and that support the policymaking process.

2. HISTORY OF POLICY ANALYSIS
Policy analysis has its roots in operations research. It evolved from operations research (in the late 1940s and early 1950s) through systems analysis (in the late 1950s and early 1960s) to policy analysis in problem-oriented work for governments carried out at the RAND Corporation and other applied research organizations in the 1960s and 1970s. Miser (1980) and Majone (1985) describe this evolution. In the beginning, operations research techniques were applied to problems in which there were few parameters and a clearly defined single objective function to be optimized (e.g. aircraft design and placement of radar installations). Gradually, the problems being analysed became broader and the contexts more complex.
Health, housing, transportation and criminal justice policies were being analysed. Single objectives (e.g. cost minimization or single variable performance maximization) were replaced by the need to consider tradeoffs among multiple (and conflicting) objectives (e.g. the impacts on health, the economy and the environment, and the distributional impacts on different social or economic groups). Non-quantifiable and subjective considerations had to be considered in the analysis (Schlesinger, 1967 provided an early discussion of this issue). Optimization was replaced by satisficing. Simon (1969, pp. 64–65) defined satisficing to mean finding an acceptable or satisfactory solution to a problem instead of an optimal solution. He said that satisficing was necessary because ‘in the real world we usually do not have a choice between satisfactory and optimal solutions, for we only rarely have a method of finding the optimum’. Uncertainty became a more important element in the analysis. And the tools (and their associated disciplines) needed to deal with the increased breadth and uncertainty expanded from an initial focus on mathematical modelling to include surveys, focus groups, scenario development and gaming.

The policy analysis process has been applied to a wide variety of problems. Miser and Quade (1985, ch. 3) provide examples of some of these, including

- improving blood availability and utilization,
- improving fire protection,
- protecting an estuary from flooding, and
- providing energy for the future.

More generally, the policy analysis approach has been used in the formulation of policies at the national level, including national security policies, transportation policies and water management policies. Other examples that illustrate the approach can be found in a variety of publications, including Drake et al. (1972), House (1982), Mood (1983, ch. 20) and Pollock et al. (1994).

More recently, RAND Europe has used the approach in a range of studies, including

- an examination of infrastructure options for the Netherlands’ civil aviation system (RAND Europe, 1997a).

Section 6 uses the last study to illustrate the policy analysis process.

3. THE CONTEXT FOR POLICY ANALYSIS

Public policy analysis is a rational, systematic approach to making policy choices in the public sector. It is a process that generates information on the consequences that would follow the adoption of various policies. It uses a variety of tools to develop this information and to present it to the parties involved in the policymaking process in a manner that helps them come to a decision. It is more an art than a science since ‘it draws on intuition as much as on method’ (Bardach, 1996, p. 1). And, as Heineman et al. (1990) state: ‘As long as human dignity and meaning exist as important values, social science cannot achieve the rigor of the physical sciences because it is impossible to separate human beliefs from the context and process of analysis’. Nevertheless, policy analysis uses the scientific method. This means that

- the work is open and explicit,
- the work is objective and empirically based,
- the work is consistent with existing knowledge, and
- the results are verifiable and reproducible.

Its purpose is to assist policymakers in choosing a course of action from among complex alternatives under uncertain conditions.

The word ‘assist’ emphasizes that policy analysis is used by policymakers as a decision aid, just as check lists, advisors and horoscopes can be used as decision aids. Policy analysis is not meant to replace the judgment of the policymakers (any more than an X-ray or a blood test is meant to replace the judgment of medical doctors). Rather, the goal is to provide a better basis for the exercise of that judgment by helping to clarify the problem, presenting the alternatives and comparing their consequences in terms of the relevant costs and benefits.

The word ‘complex’ means that the policy being examined deals with a system that includes people, social structures, portions of nature, equipment and organizations; the system being studied...
Two sets of external forces act on the system: external forces outside the control of the actors in the policy domain and policy changes. Both sets of forces are developments outside the system that can affect the structure of the system (and, hence, the outcomes of interest to policymakers and other stakeholders). These developments involve a great deal of uncertainty. The external forces themselves are highly uncertain. They include the economic environment, technology developments and the preferences and behaviour of people. The policy changes are not uncertain, but their effects on the structure of the system are. Typically, scenarios are the analytical tools that are used to represent and deal with these uncertainties. Each scenario is a description of one possible future state of the system. Scenarios do not forecast what will happen in the future; rather they indicate what can happen. Also, scenarios do not include complete descriptions of the future system; they include only factors that might strongly affect the outcomes of interest.

Policies are the set of forces within the control of the actors in the policy domain that affect the structure and performance of the system. Loosely speaking, a policy is a set of actions taken by a government to control the system, to help solve problems within it or caused by it, or to help obtain benefits from it. In speaking about national policies, the problems and benefits generally relate to broad national goals — for example, tradeoffs among national environmental, social and economic goals. A goal is a generalized,
non-quantitative policy objective (e.g. ‘reduce air pollution’ or ‘ensure traffic safety’). Policy actions are intended to help meet the goals.

For each policy goal, criteria are used to measure the degree to which policy actions can help to reach the goal. These criteria are directly related to the outcomes produced by the system. Those system outcomes that are related to the policy goals and objectives are called outcomes of interest. Unfortunately, although a policy action may be designed with a single goal in mind, it will seldom have an affect on only one outcome of interest. Policy choices, therefore, depend not only on measuring the outcomes of interest relative to the policy goals and objectives, but identifying the preferences of the various stakeholders and identifying tradeoffs among the outcomes of interest given these various sets of preferences. The exploration of the effects of alternative policies on the full range of the outcomes of interest under a variety of scenarios and the examination of tradeoffs among the policies requires a structured analytical process that supports the policy-making process.

4. THE STEPS OF POLICY ANALYSIS

The policy analysis process generally involves performing the same set of logical steps (see, for example, Walker et al., 1979, p. 70 and Findeisen and Quade, 1985, p. 123). Most projects include only a subset of the steps. The steps are not always performed in the same order and there is usually feedback among the steps. The steps are summarized in Figure 2 and briefly described below.

Step 1. Identify the problem. This step sets the boundaries for what follows. It involves identifying the questions or issues involved, fixing the context within which the issues are to be analysed, and the policies will have to function, clarifying constraints on possible courses of action, identifying the people who will be affected by the policy decision, discovering the major operational factors and deciding on the initial approach.

Step 2. Identify the objectives of the new policy. Loosely speaking, a policy is a set of actions taken to solve a problem. The policymaker has certain objectives that, if met, would ‘solve’ the problem. In this step, the policy objectives are determined. (Most public policy problems involve multiple objectives, some of which conflict with others.)

Step 3. Decide on criteria (measures of performance and cost) with which to evaluate alternative policies. Determining the degree to which a policy meets an objective involves measurement. This step involves identifying consequences of a policy that can be estimated (quantitatively or qualitatively) and that are directly related to the objectives. It also involves identifying the costs (negative benefits) that would be produced by a policy and how they are to be estimated.

Step 4. Select the alternative policies to be evaluated. This step specifies the policies whose consequences are to be estimated. It is important to include as many as stand any chance of being worthwhile. If a policy is not included in this step, it will never be examined, so there is no way of knowing how good it may be. The current policy should be included as the ‘base case’ in order to determine how much of an improvement can be expected from the other alternatives.

Step 5. Analyse each alternative. This means determining the consequences that are likely to follow if the alternative is actually implemented, where the consequences are measured in terms of...
the criteria chosen in Step 3. This step usually involves using a model or models of the system. This step is usually performed for each of several possible future worlds (scenarios).

Step 6. Compare the alternatives in terms of projected costs and effects. This step involves examining the estimated costs and effects for each of the scenarios, making tradeoffs among them and choosing a preferred alternative (which is robust against the possible futures). If none of the alternatives examined so far is good enough to be implemented (or if new aspects of the problem have been found, or the analysis has led to new alternatives), return to Step 4.

Step 7. Implement the chosen alternative. This step involves obtaining acceptance of the new procedures (both within and outside the government), training people to use them and performing other tasks to put the policy into effect.

Step 8. Monitor and evaluate the results. This step is necessary to make sure that the policy is actually accomplishing its intended objectives. If it is not, the policy may have to be modified or a new study performed.

The individual steps in the process are described in detail by Findeisen and Quade (1985) and by Quade (1989, Chapter 4). An example that illustrates the process is given in Section 6, below. First, however, some general comments about a few of the steps.

Steps 1–3 are probably the most important in the entire process. Together, they can be referred to as ‘formulating the problem’. The remainder of the steps can be referred to as ‘solving the problem’. Russell Ackoff once said: ‘We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem’. This means that a great deal of effort should be devoted to these three steps. In fact, some of the projects RAND Europe carries out deal exclusively with these three steps and the projects are viewed by the client as being very successful. Often, however, analysts give these steps short shrift. Many times, the problem statement given to the analyst is accepted without question. For example, the problem originally posed to our project team examining freight transport policy options was to find the best ways to shift freight off the highways and onto other modes. However, realizing that this was more of a solution statement than a problem statement, we asked the client why freight should be shifted off the highways. This question revealed that the goal was really to reduce the negative effects of road freight transport. But, there are ways of reducing the negative effects of road freight transport besides shifting it off the highways, such as making better use of the existing infrastructure and truck fleet. The goal of the research was, therefore, widened to include these other possibilities and the research eventually revealed that the modal shift options were the least cost-effective ways of reaching the goal.

In Steps 2 and 3, there is often little effort made to identify the objectives of the various stakeholders or to identify policy impacts spanning the concerns of all affected groups. In many cases, qualitative impacts are ignored and only quantitative impacts are assessed. It is important to realize that qualitative analysis can be a valid scientific endeavour and numerical estimates of impacts are not necessary for making policy decisions. For example, in our analysis of civil aviation infrastructure options, we estimated aircraft noise and exhaust emissions quantitatively, while we estimated the effects on safety and natural settings qualitatively. Failure to take into account the interests of all stakeholders will often lead to the results of the study being ignored by policymakers or attacked by stakeholders.

There are two important rules for carrying out Step 4. First include the existing situation as the base case. Second, include as many alternatives as stand any chance at all of being worthwhile. Do not exclude an alternative merely because it seems impractical or runs contrary to past practice. Personal judgments on such issues should be withheld. The analysis will show whether the benefits to be derived outweigh the cost of making such radical changes — or indeed, of making any changes at all.

Step 5, which usually involves the use of models, is only one step in the process and generally not the most important step. Some analysts act as if the model is more important than the problem they are trying to solve. But the truth is that models are merely the tools of the policy analyst, much as brushes are tools of the artist — they are a means to an end, not the end in itself. It is easy for an analyst to become more interested in the model than in the problem itself. Focusing attention on the mechanics of the computation or on the technical relationships in the model may neglect important questions that should be raised in
the study. Modellers may thus find out a great deal about inferences that can be drawn from the model, but very little about the question they are trying to answer. The policy analyst, however, must keep his work problem oriented, remembering that his primary job is to solve a problem, not build a model.

This leads to two important principles of policy modelling.

1. **Fit the model to the problem, not the problem to the model.** Every analyst has his own sets of tools and techniques that he is likely to want to apply to a problem. Sometimes these tools are appropriate and sometimes they are not. It is not uncommon for an analyst to make assumptions that will fit the problem to the tool he wants to use, rather than to search for the appropriate tool (or develop a new one).

2. **Use the simplest model that will do the job.** The analyst must keep in mind that he is going to have to explain his results and methodology to a policymaker who will generally not be familiar with advanced mathematics. The simpler the model the easier it will be to explain and the better the chance that the policymaker will understand the analysis. As Quade points out: ‘The most convincing analysis is one that a nontechnician can think through’ (Quade, 1989, pp. 362–363).

All of the steps of a policy analysis study should be carried out in close cooperation with the relevant policymakers and should be connected to the policymaking process. In fact, a policy analysis study should be a partnership between analysts and policymakers. This is often not the case in practice. In many policy analysis studies the analyst or consulting firm performs the first six steps on their own — perhaps interacting with the policymakers at a monthly or quarterly steering group meeting. But, in many policy analysis studies, the results do not get used. The studies may have been well designed, the models elegant and the reports produced impressive, but from a policy point of view, the study is not a success unless the results are used by the policymakers.

There are many reasons why the results do not get used. But one of the major reasons is that the policymaker(s) did not understand how the results were obtained, or did not agree with the way one or more of the steps were carried out. I believe that the single most important factor in determining whether or not the results of a study are used is the relationship between the analyst(s) and the policymaker(s). A policy analysis study should be a joint effort of the analyst(s) and the policymaker(s) — a partnership in the true sense of the word. In this partnership there should be a clear division of responsibility and differentiation of roles. The analyst(s) should do the data analysis and the modelling and should present information to the policymaker(s) in a manner that facilitates the evaluation of the alternative policies and the choice of the one to be implemented. The policymaker(s) should play a major role in defining the objectives, identifying the constraints on feasible solutions, choosing the policy to be implemented and supporting the implementation effort.

In most of the RAND Europe policy analysis studies previously cited, the work ended with the presentation to policymakers of the effects of each of the policy options. That is, we carried out only Steps 1–5. Remember that the policy analyst’s job is to provide decision support to policymakers, not to make the decisions. By carefully and conscientiously carrying out Steps 1–5, we supply much of the information that is needed by the interested parties so that a good policy choice can be made.

5. **PRESENTATION OF RESULTS**

Once the impacts have been assessed, a major difficulty still remains: synthesizing the numerous and diverse impacts and presenting the results in a way that facilitates the comparison and ranking of the tactics. Many approaches have been developed for this purpose. Most of these are aggregate approaches. In an aggregate approach, each impact is weighted by its relative importance and combined into some single, commensurate unit such as money, worth, or utility. Decisionmakers then use this aggregate measure to compare alternatives.

However, there are drawbacks to using an aggregate approach. First, the aggregation process loses considerable information: For example, it suppresses the fact that Policy A has environmental problems whereas Policy B has financial problems and Policy C has safety problems.

Second, any single measure of worth depends strongly on the weights given to the different impacts when they were combined and the as-
sumptions used to get them into commensurate units. Unfortunately, these crucial weights and assumptions are often implicit or highly speculative. They may impose on the decisionmakers a value scheme bearing little relation to their concerns. For example, traditional cost-benefit analyses implicitly assume that a euro’s worth of one kind of benefit has the same value as a euro’s worth of another; yet in many public decisions, monetarily equivalent but otherwise dissimilar benefits would be valued differently by society. Also, in converting disparate impacts into monetary values, speculative assumptions must sometimes be made, such as: What is the value of a person’s life? How much money is one dead bird worth? Are a million dead birds worth a million times one dead bird?

Third, the aggregate techniques are intended to help an individual decisionmaker choose a single preferred alternative—the one that best reflects his/her values (importance weights). Serious practical and theoretical problems arise when there are multiple stakeholders and even multiple decisionmakers. The practical problems include the need to answer the following questions: Whose values get used (the issue of interpersonal comparison of values) and what relative weight does the group give to the preferences of different individuals (the issue of equity)? The theoretical problem associated with these questions is that it has been proved that there is no rational procedure for combining individual rankings into a group ranking that does not explicitly include interpersonal comparison of preferences. To make this comparison and to address the issue of equity, full consideration of the original impacts appears essential.

We generally use a disaggregate approach in which the impacts of tactics are presented in the form of tables that Hammond et al. (1999) call consequences tables and that I call scorecards. Each column of a scorecard represents an impact and each row represents a policy option. An entire row shows all of the impacts of a single option; an entire column shows each option’s value for a single impact. Numbers or words appear in each cell of the scorecard to convey whatever is known about the size and direction of the impact in absolute terms, i.e. without comparison between cells. In comparing the tactics, each stakeholder and decisionmaker can assign whatever weight he/she deems appropriate to each impact. Explicit consideration of weighting thus becomes central to the decision process itself, as it should be. Prior analysis can consider the full range of possible impacts, using the most natural description for each impact. Therefore, some effects can be described in monetary terms and others in physical units; some can be assessed with quantitative estimates (e.g. air pollutant emissions) and others with qualitative comparisons (e.g. ‘the stakeholder acceptability for this tactic is high’). A notional scorecard is shown in Figure 3.

A disadvantage of this approach is that the amount of detail can make it difficult for the decisionmakers to see patterns or draw conclusions. To aid decisionmakers in recognizing patterns and trading off disparate impacts colouring of the boxes of the scorecard can be used, e.g. blue for best policy option for this impact, yellow for intermediate and red for worst. This shows the ranking of the impact values across rows, for each column independently of all other columns. Tradeoffs among impacts can be made by making comparisons between columns. Another decision aid is to prepare a summary scorecard for each impact category (e.g. a safety scorecard, an environment scorecard, an economy scorecard, etc.).

The scorecard approach has several advantages. It makes it possible to present a wide range of impacts and permits each stakeholder and decisionmaker to give each one whatever weight he/she deems appropriate. Applying some method where impacts are weighted requires additional calculations or the use of specific programs. It helps them to see the comparative strengths and weaknesses of the various policy options, to consider impacts that cannot be expressed in numerical terms and to change their set of weights and note the effect that this would have on their final choices. In the case of multiple decisionmakers, the scorecard has the additional advantage of not requiring explicit agreement on weights for different social values. It is generally much easier for a group of decisionmakers to determine which alternative they prefer (perhaps for different reasons) than what weights to assign to the various impacts. A more complete discussion of scorecards can be found in Goeller et al. (1977, pp. 10–13); Miser and Quade (1985, pp. 89–108) also illustrate their use.
6. A POLICY ANALYSIS CASE STUDY: THE TNLI PROJECT

6.1. Introduction
The TNLI (Toekomstige Nederlandse Luchtvaart Infrastructuur or Future of Dutch Civil Aviation Infrastructure) project was a broad policy study focused on ways of coping with the projected growth in air transport demands in the Netherlands. The project was carried out during the period August 1995–October 1996 by RAND Europe for three Dutch ministries: the Ministry of Transport, Public Works and Water Management, the Ministry of Housing, Spatial Planning and Environment and the Ministry of Economic Affairs. With the support and active participation of staff members of these ministries, a set of policy analysis tools was designed and built to assess the impacts of the various policy options and identify promising options to help achieve the policy goals.

The following subsection describes the problem addressed and the overall approach of the project. Subsections after that describe the scenarios that were developed, the criteria that were used for assessing the effects of the infrastructure options, the impact assessment models that were used to assess the impacts of the options, the options themselves and the results of the impact assessment. For a complete description of the project and its results, see RAND Europe (1997a).

6.2. Problem statement, context and overview of project
In 1996, the Dutch Government was in the midst of a reassessment of its policies related to civil aviation caused in large part by the fact that the growth in commercial civil aviation traffic in the Netherlands had exceeded expectations. One of the inputs to the reassessment was an analysis that investigated possible future developments of demand and capacity of air transport, alternative infrastructure options that could be implemented to meet these future situations and societal demands and expectations that would influence the choice among those alternatives.
Air transport benefits the Dutch economy in many ways. Approximately 70000 people are directly employed by airports and airlines in the Netherlands. The availability of a wide range of high quality air services in the country also helps create a favorable investment climate and promotes international trade. Nevertheless, the direct and indirect environmental effects of air transport at both the local and global levels are increasingly becoming problems that need to be addressed. In addition, regions close to airports suffer other negative effects, such as surface traffic congestion and aircraft noise. These negative effects tend to increase as the air traffic increases. These facts, together with discussions with members of the client organizations, resulted in the following statement of the question to be addressed by the TNLI project.

The demand for infrastructure for civil aviation transport in the Netherlands may continue to increase. Activities related to civil aviation have social, economic, safety, environmental, spatial, accessibility, and cost consequences. The question the nation must answer is whether or not to accommodate the demand in light of these consequences, and, if so, how.

The commercial aviation system of the Netherlands can be divided into two parts: the supply system and the demand system. The main elements of the supply system are the airlines, the air traffic control system and the national and regional airports. The infrastructure options analysed all related to changes in the supply of airport capacity. The demands considered in the analysis are passenger and cargo demands for transport to, from, or through the Netherlands. The planning horizon for the project was chosen to be the year 2025 and beyond (we refer to this time horizon as 2025+).

The project used the policy analysis approach described above to clarify the problem, outline the alternative solutions and display tradeoffs among their consequences. The policy analysis approach as applied in the TNLI project is shown in Figure 4.

After the problem was formulated and the system described (as presented above), we proceeded to carry out the following steps:

- defining scenarios,
- defining criteria (impacts),
- defining policy options (tactics),
- building impact assessment models, and
- describing results.

These efforts are summarized below.

6.3. Scenarios

The evaluation of alternative infrastructure options needs to take place in the context of the future world in which they will have to function. But the future is uncertain. One way to deal with this uncertainty is to construct alternative possible scenarios and look for options that perform...
reasonably well in some or all of them. A scenario is a description of a hypothetical future state of the world, including a consideration of the major uncertainties encountered in moving far into the future. The scenarios do not predict what will happen in the future; rather they are plausible descriptions of what can happen. They pay attention to developments within the system and to those outside the system that affect the system, excluding the infrastructure options to be examined. We constructed five scenarios for a year 2025 that focus specifically on (1) the world of civil aviation and (2) changes both inside and outside the civil aviation system that are relevant for making policy decision about investments in civil aviation related infrastructure in the Netherlands. They are not an inventory of all the changes affecting civil aviation that can occur in the future — encompassing all possible changes in five scenarios is impossible. However, they cover the range of plausible future demands; each scenario, although a single point in the array of possible futures, represents a family of changes that fall within the category represented by the scenario.

The five scenarios differ in terms of the assumptions that are made about (1) worldwide growth of civil aviation, (2) the configuration of the civil aviation system in Europe, (3) civil aviation policies within the European Union, (4) the development of competing transportation systems, (5) airport capacity in Europe and (6) aircraft technology. Table I gives an overview of the five scenarios. For more details on the scenarios and their development, see RAND Europe (1997b).

6.4. Criteria for assessing the effects of the infrastructure options
During the initial phases of the project we held roundtable meetings with representatives of many of the stakeholder groups (e.g. Dutch airport owners and users, national environmental interest groups). Based on these meetings, examination of the literature and additional internal and external discussions, we identified a set of quantitative and qualitative criteria. The resulting criteria were used in the analysis to assess a particular ‘case’ (combination of infrastructure option and scenario). Table II gives an overview of the categories and types of criteria that were used in the analysis. Appendix D of RAND Europe (1997a) provides a complete list of the criteria used.

Table I. Scenarios for 2025+ for the TNLI project

<table>
<thead>
<tr>
<th>Scenario no.</th>
<th>Worldwide civil aviation</th>
<th>Role of the Netherlands</th>
<th>Annual passenger movements</th>
<th>Annual tonnes of cargo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Growth</td>
<td>One of six hubs</td>
<td>~103 million</td>
<td>~7.7 million</td>
</tr>
<tr>
<td>2</td>
<td>Growth</td>
<td>No hub</td>
<td>~40 million</td>
<td>~2.3 million</td>
</tr>
<tr>
<td>3</td>
<td>Growth</td>
<td>One of ten hubs</td>
<td>~64 million</td>
<td>~4.6 million</td>
</tr>
<tr>
<td>4</td>
<td>Downturn</td>
<td>One of three hubs</td>
<td>~82 million</td>
<td>~10.0 million</td>
</tr>
<tr>
<td>5</td>
<td>Downturn</td>
<td>No hub</td>
<td>~14 million</td>
<td>~0.8 million</td>
</tr>
</tbody>
</table>
6.5. Infrastructure options

Based on meetings with the client organizations and on other sources and discussions, we specified a set of infrastructure options to be examined in the analysis. Options that varied the number of regional airports were excluded, since we assumed that the role of regional airports in the Netherlands was unlikely to grow in a world dominated by hub-and-spoke airline networks. An infrastructure option was, therefore, defined to be a configuration of national airport(s), where a national airport is defined as an airport that is able to accommodate large volumes of passengers and/or cargo and that can function as a hub.

The infrastructure options were defined in terms of the following key characteristics:

- the number of national airports in the Netherlands (one or two),
- in case there are two national airports, whether the traffic at the airports is allocated based on: type of traffic (intra-European versus intercontinental), hub-carrier, or purpose (pure cargo versus mainly passengers),
- the location of (the parts of) the airport (densely populated area; sparsely populated area; in the sea; at the border).

In assessing the effects of an infrastructure option for a particular scenario, we assumed that all demand for air transport in that scenario would be accommodated; i.e. the national airport(s) would be sized to meet the national demands. This means that no demand would be shifted from national to regional airports because of capacity constraints. It also means that the physical and/or environmental capacity of an airport, in terms of aircraft movements, passenger movements and tonnes of cargo, is not part of the description of an infrastructure option.

The fourteen primary infrastructure options we examined are described below and summarized in Figure 5.

6.5.1. 1–4. N2popa, N2lake, N2sea and N2spa

There are two completely separate national airports in the Netherlands, which are not linked by a dedicated high speed people/cargo mover. The

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Figure 5. Infrastructure options examined.
two national airports are connected by public transport. One of the two national airports is Schiphol. The second airport is located in the sea, in a lake, or on land (in a populated area or a sparsely populated area). Traffic is allocated between the airports based either on type of traffic (intra-European versus intercontinental) or hub-carrier (one hub at each airport).

6.5.2. 5–6. N2 cargo (popa and lake)
There are two completely separate national airports in the Netherlands, which are not linked by a dedicated high speed people/cargo mover. The two national airports are connected by public transport. One of the two national airports is Schiphol. The second airport is built to handle only cargo and can be built in a populated area or in a lake. All of the cargo is intercontinental cargo and only full freighters are used at the cargo airport. There is no express cargo handled at the cargo airport.

6.5.3. 7–9. RRpopa, RRlake and RRsea
The terminals remain in the current location at Schiphol. The runways at Schiphol with the highest noise effects are closed down. Remote runways are located at a water location, or on land. The remote runways are connected to the terminals by an underground people/cargo mover, capable of very high speeds. There is no other landside connection besides the people/cargo mover. The noisiest aircraft and all night flights are assumed to use the remote runways.

6.5.4. 10. N1popa
All demand is accommodated at Schiphol (located in a densely populated area). Facilities are enlarged as needed in the scenario.

6.5.5. 11. N1lake
Schiphol is closed and there is a single national airport located on an artificial island in a lake. The airport handles all types of transport and is connected to the mainland by a land bridge.

6.5.6. 12. N1sea
Schiphol is closed and there is a single national airport located on an artificial island in the sea. The airport handles all types of transport and is connected to the mainland by a land bridge.

6.5.7. 13. N1spa
Schiphol is closed and there is a single national airport in a sparsely populated area, non-econo- nomic center. The airport handles all types of transport.

6.5.8. 14. N1border
Both Schiphol and Zaventem (Brussels) airports are closed or have a reduced role. There is a single national airport located on land somewhere on the Dutch/Belgian border. The airport handles all types of transport. For assessing this option, we assumed that the direct economic costs and benefits are split between the Netherlands and Belgium.

6.6. Impact assessment models
Impacts of the various infrastructure options were estimated using both qualitative and quantitative (computer) models. The models were designed to explore the implications of uncertainties in the future world of civil aviation for policy decisions regarding civil aviation infrastructure, to provide a level playing field for comparing alternative infrastructure options and to provide insights into the costs and benefits of the infrastructure options for the various scenarios. Computer models were developed for estimating demand, economic effects, costs, noise, aircraft exhaust emissions and ground access emissions associated with the scenarios and infrastructure options. Figure 6 shows how the computer models fit together conceptually.

The demand model produces a set of numbers for a scenario that represent estimates of future demands based on the assumptions for that scenario. The demands are given in terms of the number of aircraft movements, tonnes of cargo, aircraft mix, number of origin/destination (O/D), transfer, business and leisure passengers and the share of these passengers carried by the home carrier and by foreign carriers.

Figure 6. Interrelationships among computer models.
The model used to estimate national economic effects uses the demand model's estimates of passenger, cargo and aircraft movement volumes to estimate the effects of the resulting civil aviation activity on employment, value-added and demand for land, office space and land transport. The model considers the economic picture painted by the scenario, as well as the specifics of the infrastructure option (the number, location and function of national airports). Both direct and indirect employment effects are estimated. The direct effects are those jobs that are directly related to aviation activities in the Netherlands. Indirect effects are jobs created by intermediary deliveries and by the attractiveness of an airport and its location.

The noise model and the aircraft emissions model use the number of aircraft movements by aircraft type from the demand model to estimate their impacts (an indicator for the ground surface within a specified noise immission contour1 and total exhaust emissions of the landing and takeoff cycle of all flights up to 10000 feet, respectively).

The ground access emissions model uses the demand figures to estimate the emissions generated by O/D passengers, employees and cargo travelling to and from the airport.

The cost model estimates the financial cost of providing capacity at the national airport(s) to meet the demand estimated for a given case.

The numbers produced by the models are not important in themselves. It is the relative differences in those numbers that are important. The most important objective of the assessment of infrastructure options was to provide insights into the relative performance of the options in each scenario. In other words, for a given scenario and measure of performance, the assessment was intended to shed light on which options performed best. Our intention was to be able to make the following sorts of statements: for some given level and composition of demand (i.e. a scenario), Option A is better than Option B in terms of cost and environmental effects, but not as good in terms of its economic effects. The quantitative information from the computer models and the information from the qualitative models were placed on scorecards that were used to compare the relative advantages and disadvantages of the various infrastructure options.

6.7. Assessment of infrastructure options

The assessment of each infrastructure option was carried out for each of the five scenarios. Each combination of a scenario and an option was defined to be a separate case. The assessment of a case on the set of qualitative and quantitative criteria was done relative to a comparison point. Two major insights were developed in carrying out the assessment. First, the relative ranking of the infrastructure options on each of the performance measures was found not to differ by scenario. Second, the important policy conclusions about the fourteen infrastructure options could be summarized by discussing them in terms of six ‘themes’.

The first insight is based on grouping the five scenarios into two categories: scenarios that have high growth in demand for air travel in the Netherlands and those that do not. In the two low/no growth scenarios (Scenarios 2 and 5), the air transport demands do not exceed the existing capacity constraints at Schiphol, so there would be little need to change existing policy or build new infrastructure in order to accommodate the demand. Therefore, the detailed results of the assessments of the infrastructure options for these two scenarios could be ignored. In the remaining three scenarios, the relative performance of the infrastructure options for a given criterion remains virtually unchanged. So, presenting the results of the assessment for any one of the scenarios would be sufficient.

We grouped the assessments of infrastructure options into six themes: a land airport, remote runways, two national airports, a border airport, a water airport and a separate cargo airport. As an illustration, the assessment of a water airport is presented below.

A water airport located in a lake or the sea would drastically reduce or fully eliminate the problems associated with third-party risk, aircraft noise and local emissions. It would also eliminate the problem of urban sprawl around the runways that might constrain future airport expansion. But, if there were a landside connection to the mainland, a water airport might be a way to

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1 Noise *immissions* are the total noise individuals experience on the ground from overflying aircraft. Noise *emissions* are the sounds produced by the aircraft engines. Noise immissions are affected by such things as the distance between the individual and the aircraft, weather and wind conditions, and whether it is day or night.
stimulate regional economic development. Figure 7(a), (b) and (c) shows how noise and ground access emissions could be reduced by a sea location. (The noise bars for the sea location and land location are shaded differently to indicate that, while noise is emitted around the sea location, it would probably not cause much nuisance or annoyance.)

The major drawback to building a new airport at a water location is the cost of doing so. Building an airport at a water location is significantly more expensive than building a comparable airport at a land location. A water location is also more vulnerable to the weather than a land location. Also, because airport employees cannot live close to the airport, their commuting times would increase. This has negative repercussions for the environment as well. In addition, an airport at a water location can cause new ecological problems. Finally, locating a railway station near a water location would require additional infrastructure investments.

In summary, a water location has the potential to completely eliminate the problems associated with aircraft noise and third-party risk. However, the scale of such construction would cause new environmental problems. Such an airport would also be very expensive. Thus, the reasonableness of such an option depends on the value attached by society to eliminating aircraft noise and third-party risk. Also, if demand is to be accommodated and no land is available for a new airport or expansion of Schiphol is ruled out, an airport in the sea or a lake may be the only viable option.

6.8. Use of the project’s results
Because the policy analysis approach that was used in the project was clear and straightforward, the public and government officials were quickly able to understand the information it provided. The results have proved to be very useful, primarily to identify the infrastructure options that should be examined more carefully and those that should not be investigated further. For example,
prior to the project, the Netherlands was seriously considering the possibility of building a second national airport. However, our analysis of four such options (infrastructure options 1–4 in Figure 5) showed that the requirements included very high passenger demand, a high-speed link between the two airports, a hub carrier at each airport and lack of excess capacity at competing airports.

Subsequent attention has focused on an airport located on an artificial island in the North Sea (infrastructure option 12) and Schiphol expansion (infrastructure option 10). As described above, an airport in the sea would drastically reduce or totally eliminate the problems associated with third-party risk, aircraft noise and local emissions. However, it would be extremely expensive. By contrast, expanding Schiphol is the least costly and least disruptive option. All other infrastructure options would necessitate a redesign of airspace. Also, when compared to building an entirely new airport on a virgin site, the expansion of Schiphol is less disruptive in terms of new intrusion on natural settings and new visual intrusion. Its expansion would require less new construction than any other option, which also means that expanded Schiphol would have all the problems of a large airport located in a densely populated area. For example, it would expose large numbers of people to aircraft noise. Third-party risk could also increase with an increase in aircraft movements and airport-related traffic would interfere with other road users around the airport, exacerbating an already problematic situation.

The project has been followed up by several more detailed studies (including engineering studies and environmental impact studies), which have concentrated on these two options.

7. FINAL OBSERVATIONS

Many operations research tools, such as decision analysis, simulation and optimization, have been very successful. They are still useful and relevant as tools in many contexts. However, the complex and uncertain world of public policymaking requires applying what in marketing theory terms might be called customer-based marketing, rather than technology-based marketing. In technology-based marketing, the product is designed first and a market/customer sought out second. Customer-based marketing seeks to understand the customer first and then create the product second. The key factor in choosing which style of marketing to do is the cost of failure. When the cost of a failed offering is relatively low, technical marketing is preferred. When costs are high (as in the case of a new automobile), customer marketing is preferred. So, in providing decision support for public policymakers, a choice must be made: are you involved in technology-based marketing (the approach generally followed by methodologists) or customer-based marketing? For most real-world policy problems, a customer-based approach is more appropriate. This means starting with the problem, not with the product. The policy analysis process is customer based.

The profession of operations research is alive and well and its problem solving tools are needed and used more than ever. But it would contribute to its image and success if it expanded its frame of reference and re-defined its role in the decision-making process. Since one of the primary goals of operations research is to help decisionmakers when they have to make a choice among alternative options, its tools are perfectly suited to policy analysis. But it would be more successful if it paid more attention to the steps of policy analysis in addition to the modelling step (i.e. if it were customer based rather than technology based). For most real-world decision problems, the steps before modelling are characterized by an imaginative and somewhat unstructured exploration of the objectives of the decisionmakers, the roles of other stakeholders, the scope of the policy domain, the major uncertainties and the search for promising alternatives. These steps set the agenda for the subsequent data collection, the development of scenarios and the building of models to be used in the evaluation of the alternative options. In the steps after modelling, the scientific insights obtained in the analysis have to be transferred into the political arena. They, therefore, have to be presented to the decisionmakers in terms that they understand and can use; that is, in a form that enables them to draw the relevant conclusions, to select a strategy and to present the decision to the wider group of stakeholders. The policy analysis approach presented in this paper seeks to solve problems by carrying out these steps and by using appropriate tools from a large toolkit rather than focusing on a single tool.

Many research opportunities still remain within the various steps in the process and in tool development. In fact, policy analysis as currently
practiced has many critics and still has many pitfalls and limitations to be overcome. Laurence Lynn (1999) discusses many of these criticisms, pitfalls and limitations. Most are focused on the need to move policy analysis away from a ‘rational’, technical, decisionmaker focus toward a more qualitative, soft-science, participative focus. As Alice Rivlin (1971) states: Policy analysts have to learn that ‘educators, doctors, civil servants… even generals’ are ‘knowledgeable, necessary, and not always wrong’. And Kathleen Archibald (Majone and Quade, 1980, pp. 193–194) writes that ‘when it comes to examining pitfalls [of policy analysis], we find that the most serious pitfalls will not be circumvented by greater rigor or improved technical skills. Competencies usually considered “softer” — imagination, judgment, interpretive skills — are just as important’. The major challenges for traditional policy analysts, therefore, are

- to make the linkages between the policy analysis process and the policymaking process more effective,
- to improve the integration of stakeholders and other actors besides decisionmakers into the policy analysis process, and
- to add more ‘soft science’ tools (such as seminar games Kahan et al., 1992 and process management de Bruijn and ten Heuvelhof, 1993) to their methodological toolkits.

I believe that, as a group, the policy research community already possesses the best set of tools and qualifications to help society address the seemingly intractable problems caused by the complexity, uncertainty and system interconnectivity facing public policymakers at this point in the development of civilization. There is a great need for people who can provide sound guidance and advice. Many professionals, ranging from architects to philosophers and journalists, believe that they can solve the social problems of the world. But I truly believe that we are uniquely positioned to help improve public policy and the quality of life of people throughout the world and we should try to do so.

I cannot express my message to persons interested in providing decision support to public sector decisionmakers any better than Donald Schön did when he wrote:

In the varied topography of professional practice there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing ‘messes’ incapable of technical solution. The difficulty is that the problems of the high ground, however great their technical interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern. (Schön, 1983)

I urge those researchers who are truly interested in providing decision support to the public sector to pack their toolboxes with as wide a variety of tools as they can master and spend some more time with me down in the swamp. The rewards, both personal and professional, can be immense.

REFERENCES


