POLSSS--Policy for Sea Shipping Safety:
Executive Summary

MR-1043-RE/VW
(RE-98.005)
The research described in this report was supported by the Transport Safety, Directorate, Directorate-General for Freight Transport, Netherlands Ministry of Transport, Public Works and Water Management.
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Preface

This report provides a brief overview and summary of the results of a study that was performed for the Directorate for Transport Safety of the Directorate General for Freight Transport (DGG) of the Netherlands Ministry of Transport, Public Works, and Water Management. The study was carried out by a consortium consisting of RAND Europe, which is a part of RAND, and the Maritime Simulation Centre the Netherlands (MSCN), which is part of MARIN. The study, Policy for Sea Shipping Safety (POLSSS), is the final phase of a project entitled project systematisering veiligheidsbeleid Noordzee (PSVN), which defined a framework for decisionmaking with regard to the safety of shipping and the environment in the North Sea and areas around Dutch seaports and approaches. The final phase of the PSVN project called for an assessment of the costs and benefits of individual policy instruments as well as combinations of these instruments, a survey of the perceptions of stakeholders about the safety situation in the North Sea and surrounding areas, and a survey of the perceptions of stakeholders about the effectiveness of various policy instruments for maintaining safety in the North Sea and surrounding areas. This final phase, the POLSSS study, was carried out during the period from the middle of 1997 through the end of 1998.

A complete description of the research carried out on the POLSSS project is contained in this executive summary, two main reports, and a supporting volume. The two main reports are:

- **POLSSS — Policy for Sea Shipping Safety: Cost-Effectiveness Analysis, RE-98.006.1, by W. E. Walker, M. Pöyhönen, J.H. de Jong, and C. van der Tak.** This report describes the cost-effectiveness analysis of a range of possible policy changes.

- **POLSSS — Policy for Sea Shipping Safety: Surveying Stakeholders About Acceptability of Risks and System Changes, RE-98.007, by M. Pöyhönen, W.E. Walker, A. Lotstra, and C. van der Tak.** This report describes two surveys that were conducted in order to assess stakeholder perceptions about (1) the acceptability of risks involved in maritime activities, and (2) the effectiveness of a variety of current policies and possible policy changes.

The supporting volume, which provides details about each of the policy changes (called tactics) that were included in the cost-effectiveness analysis, is:

- **POLSSS — Policy for Sea Shipping Safety: Tactic Information, RE-98.006.2, by W. E. Walker, M. Pöyhönen, J.H. de Jong, and C. van der Tak.**

The structure of the cost-effectiveness analysis, its conclusions, and the results of the surveys should be of direct interest to maritime safety policymakers in the Netherlands and elsewhere. Indeed, many of the conclusions and much about the methodology should be directly applicable to maritime safety issues being faced by other governments.

RAND Europe is an independently chartered European subsidiary of RAND, whose offices are located in Leiden. The mission of RAND Europe is to conduct objective, independent, high-quality policy analysis that informs public and private sector decisionmaking throughout Europe.
MSCN is a department of MARIN, whose offices are located in Wageningen. MSCN conducts maritime safety studies through analysis of traffic flows and their composition around ports and approaches and on open seas. Other areas of concentration for MSCN include the examination of nautical safety in relation to port and fairway infrastructure and the use of simulators for offshore maritime training.

For further information about the POLSSS project, or to request copies of the other reports produced by the project, contact its project leader

Dr. Warren E. Walker
RAND Europe
Newtonweg 1
CP 2333 Leiden, the Netherlands
Tel: +31-71-5245151
E-mail: warren@rand.org

For more general information about the project and how its results are being used by the government of the Netherlands, contact

drs. Wim van Urk
Traffic Management Division
Transport Safety Directorate
Directorate-General for Freight Transport
Ministry of Transport, Public Works and Water Management
P.O. Box 20904
2500 EX The Hague, the Netherlands
Tel: +31-70-3511558
E-mail: wim.vurk@dgg.minvenw.nl
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Policy analysis projects usually involve the assistance of many individuals and organizations. The POLSSS project required a great deal of such help and was fortunate to have received it. Help was needed because of the diversity of the topics considered, our dependence on other individuals and organizations for essential information, and the political nature of aspects of the process.

When help is received from so many sources, it is difficult to individually thank everyone who contributed in some way. We mention a few names here and provide a more inclusive list in Appendix A. Of course, acknowledging various individuals and organizations does not imply that those who assisted us are responsible for, or agree with, our findings. The responsibility for any shortcomings rests solely with us, the authors.

Some of the most important participants in the project were several members of the Transport Safety Directorate of the Directorate General for Freight Transport (DGG) of the Netherlands Ministry of Transport, Public Works, and Water Management who served as members of a joint RAND Europe/MSCN/Ministry Project Group. The group met regularly to review the project's status, identify the next steps to be taken, assign responsibilities for the next steps, and provide liaison with the regional nautical authorities and the policymakers in the Ministry. Throughout the project, they participated in the research and gave helpful advice and information. They also read this document and suggested revisions to it. The Ministry members of the Project Group were:

   drs. W. van Urk (Leader)
   G.H. van der Ent
   drs. H. van Heems
   mr. L.P.M. van der Meij
   ir. W.A. de Vries

A Steering Group was also formed. It provided guidance on the scope and emphasis of the research and had the policy conclusions presented to it. The Steering Group was chaired by Mr. K. Polderman, Head of the Traffic Management Division of the Transport Safety Directorate of the Ministry. His dedicated support of our work was crucial to the project's success.

The other members of the Steering Group were:

   ir. M.G. Koopmans, Senior Policy Advisor for Traffic Provisions, DGG
   J. Nipius, Senior Policy Advisor for the North Sea, DGG
   D. van den Brand, Cargo and Risk Management Division, DGG
   ir. G.H. Doornink, Head of the Transport Means Division, DGG
   mr. ir. J.W. Daamen, Rijkswaterstaat, Zeeland Directorate

We were also fortunate to have the assistance of an advisory group (Beheerdersgroep), consisting of representatives of many of the regional nautical authorities in the country. Their advice was very helpful in assuring that the results from POLSSS would be useful in practice. The members of the Beheerdersgroep were:
A.P Margadant, Rotterdam Municipal Port Management
Capt. W.Ph. van Maanen, Rotterdam Municipal Port Management
A.D.F. Hiemstra, Port Management of Amsterdam
Lic. Capt. J.W.P. Prins, Rijkswaterstaat, Zeeland Directorate
Ing. K.H. Annema, Rijkswaterstaat, North Netherland Directorate
J. Ricken, Netherlands Coast Guard Center
J.H. Molenar, Royal Navy, Den Helder

We acknowledge the assistance of several of our RAND Europe colleagues. Although not co-authors of any of the reports, they made valuable contributions at several points in the study. Several other persons were very helpful in other aspects of the project. Dr. John Stoop of the faculty of System Engineering, Policy Analysis and Management of the Delft University of Technology, and Dr. James Bigelow of the RAND Corporation in Santa Monica, California, reviewed an early version of the report that described the cost-effectiveness analysis. Dr. Julie Brown from Survey Research Center of RAND and Dr. John Stoop of the faculty of System Engineering, Policy Analysis and Management of the Delft University of Technology reviewed an early version of the survey report. Their comments assisted in improving the quality of these reports.

As part of the process of understanding maritime safety, policy options that might be taken to improve safety, and ways of estimating the consequences of those options, we met with many individuals. These persons worked for the government, for research organizations, and for groups concerned with maritime shipping. We are grateful for their assistance. The names and affiliations of these persons are included in Appendix A.
## List of Terms and Abbreviations

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<th>Description</th>
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<tbody>
<tr>
<td>CP</td>
<td>Contingency Planning</td>
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<tr>
<td>DGPS</td>
<td>Differential Global Positioning System</td>
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<tr>
<td>Differential Navigational Support</td>
<td>A new set of piloting procedures used solely for this study under which, depending on its length, a vessel would get VTS support, get VTS and VTS navigational assistance, be remotely piloted following the current LOA procedure, or be normally piloted with a pilot on board.</td>
</tr>
<tr>
<td>Disaster</td>
<td>A catastrophic event that has large and serious consequences.</td>
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<tr>
<td>Disaster scenario</td>
<td>A detailed specification of one possible disaster -- for example, a specific oil tanker accident.</td>
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<tr>
<td>ECDIS</td>
<td>Electronic Charts Display Information System</td>
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<tr>
<td>ERI</td>
<td>Ecological Risk Indicator</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>Impact</td>
<td>A consequence of the implementation of a tactic. Many of the impacts are estimated using models.</td>
</tr>
<tr>
<td>Impact assessment</td>
<td>The stage in the cost-effectiveness analysis in which the impacts of the tactics are estimated.</td>
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<tr>
<td>KNRM</td>
<td>Koninklijke Nederlandse Redding Maatschappij (Royal Dutch Rescue Association)</td>
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<tr>
<td>LOA</td>
<td>Loods op afstand -- remote piloting (with no pilot on board).</td>
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<tr>
<td>MANS</td>
<td>Management Analysis North Sea; within POLSSS MANS refers to the shipping traffic databases within MANS and to the models calculating changes in the number of different types of calamities and their consequences.</td>
</tr>
<tr>
<td>MNLG</td>
<td>Millions of Netherlands Guilders</td>
</tr>
<tr>
<td>NCP</td>
<td>Nederlandse Continentaal Plat -- the Netherlands’ portion of the Continental Shelf.</td>
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<tr>
<td>NEREUS</td>
<td>A network between the Coast Guard Center and Dutch seaports for the exchange of information on hazardous and polluting goods on board.</td>
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<tr>
<td>Abbreviation</td>
<td>Definition</td>
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<tr>
<td>RACON</td>
<td>RAdar beaCON -- a waterway marking that sends a signal in response to a radar scanner that is detected by the radar on board vessels.</td>
</tr>
<tr>
<td>RAMFOS</td>
<td>Risk Assessment Model For Oil Spills (a part of MANS)</td>
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<tr>
<td>Region</td>
<td>Distinct geographic area defined specifically within POLSSS in order to make relevant distinctions with respect to the costs and benefits of tactics and the practicability of their application.</td>
</tr>
<tr>
<td>SAR</td>
<td>Search And Rescue</td>
</tr>
<tr>
<td>Strategy</td>
<td>A combination of tactics.</td>
</tr>
<tr>
<td>Tactic</td>
<td>A single action whose implementation is intended to help solve one or more of the problems in vessel traffic management (cost can be one of the problems).</td>
</tr>
<tr>
<td>TSS</td>
<td>Traffic Separation Scheme</td>
</tr>
<tr>
<td>VTM</td>
<td>Vessel Traffic Management</td>
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<tr>
<td>VTMIS</td>
<td>Vessel Traffic Management Information Services</td>
</tr>
<tr>
<td>VTS</td>
<td>Vessel Traffic Services</td>
</tr>
<tr>
<td>WAKER</td>
<td>The name of a Coast Guard salvage vessel operating in Dutch waterways.</td>
</tr>
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1. Introduction

1.1. The POLSSS Project

The Policy for Sea Shipping Safety (POLSSS) project was commissioned by the Directorate for Transport Safety, which is part of the Directorate-General for Freight Transport (DGG) within the Ministry of Transport, Public Works, and Water Management. Begun in August 1997, the project was carried out by a team of researchers from RAND Europe and the Maritime Simulation Centre the Netherlands (MSCN). A Ministry Project Group provided support and coordination for data collection and work with other contractors, as well as guidance and advice for the project. In addition, a Steering Group composed of representatives from various offices within the ministry periodically reviewed the research progress and offered strategic guidance. A group of representatives from many of the country's regional nautical authorities (*Beheerdersgroep*) also provided information and advice.

1.2 Background

The North Sea is one of the busiest shipping areas in the world. Also, maritime activities in Dutch seaports make a major contribution to the Dutch economy. For example, the direct added value of maritime activities in Dutch seaports (including the fishing industry and offshore oil and gas platforms) was estimated in 1990 at NLG 27 billion (5.6% of the Dutch GNP), and the employment that can be ascribed to activities in Dutch seaports amounted to jobs for 156,000 people (2.8% of the total employment in the Netherlands) [NEI, 1993]. Recognizing the amount of maritime activity and its economic importance, the Ministry formulated a maritime vessel traffic management (VTM) policy that has three main objectives [Ministry of Transport, Public Works and Water Management, 1987]:

1. To create conditions that ensure a safe and efficient flow of shipping traffic to and from Dutch ports.
2. To ensure a careful balancing of the interests of shipping traffic and the interests of other users.
3. To create conditions for safe traffic flow along the Dutch coast.

In 1997, the Directorate General of Shipping and Maritime Affairs published a policy report which concluded that the Netherlands Continental Shelf (the Dutch portion of the North Sea) and the harbor approaches around the North Sea can be regarded as safe [Ministry of Transport, Public Works and Water Management, 1997, p.2]. This outcome was seen as the result of a successful policy based on thorough research about policy instruments and their impacts.
However, there were some remaining questions about the effectiveness and efficiency of the combination of policy instruments currently being used for maintaining the safety of shipping and other users in the North Sea. While it is clear that each of the individual policy instruments enhances safety, it is not equally clear that the current combination of policy instruments represents the most cost-effective combination for maintaining and enhancing safety in the North Sea. In addition, there are questions about what will need to be done in the future to maintain safety in the North Sea. It is clear that, as the context of the maritime shipping system changes, new policy instruments and modifications to existing policy instruments will be needed in order to maintain or improve the safety situation in the North Sea.

Two policy assumptions underlying the development of a traffic management policy were to be [Ministry of Transport, Public Works and Water Management, 1997, p.10]:

- "Improving (cost-) effectiveness and efficiency by a coherent use of different measures and facilities;"
- "Improving flexible and specific adjustment of measures and facilities on the basis of systematic measurements and evaluation of relevant developments in traffic patterns and incident/risk levels."

There was also an explicit desire to use "a more systematic and methodical approach to the policy... This would allow for better measurements and evaluation of the effects of existing policy, and... would make possible better assessment of newly proposed measures on their merits (such as cost-effectiveness)." [Ministry of Transport, Public Works and Water Management, 1997, p.8]

1.3 The Research Problems

The project systematisering veiligheidsbeleid Noordzee (PSVN) [DGSM, 1991-1993] has been describing the Dutch shipping safety policy. It is doing this by defining a framework for decisionmaking with regard to the safety of shipping and the environment in the North Sea and areas around Dutch ports and harbors. This framework covers the evaluation of impacts of currently-used policy measures, as well as the prediction of the impacts of new measures that might be implemented sometime in the future. The final phase of PSVN called for: (1) an assessment of the costs and effects of individual policy instruments as well as combinations of these instruments; (2) a survey of the perceptions of stakeholders about the safety situation in the North Sea and areas around Dutch ports and harbors; and (3) a survey of the perceptions of stakeholders about the effectiveness of policies for maintaining safety in these areas. The POLSSS study constitutes the final phase of PSVN.

Work on POLSSS was divided into two parts: (1) a cost-effectiveness analysis of policy instruments, and (2) two surveys of stakeholders. This report provides overviews and summaries of the results of both efforts.
The cost-effectiveness analysis considered most types of shipping accidents and maritime disasters, and aimed to:

- Define a set of new possible policy measures,
- Evaluate the costs and benefits of the new measures,
- Determine whether there are measures that can improve safety or reduce costs in the North Sea and surrounding areas.

The second part of the POLSSS project consisted of two surveys that were conducted to obtain information on stakeholders' perceptions about the safety situation in the North Sea and surrounding areas and about their perceptions of the current and possible new policy measures. The objectives of this part of the POLSSS project were to collect information from stakeholders about their:

- perceptions of the effectiveness of the existing policy for maintaining safety of sea shipping in North Sea and harbor areas,
- willingness to accept the risk of certain types of shipping accidents and maritime disasters,
- perceptions of the extent to which the policy objectives of current policies have been reached,
- future needs.

The survey results were then linked with the cost-effectiveness analysis, where preference was given to those measures that were most acceptable to the stakeholders.

The activities in the two parts of the project, and their inter-relationships, are shown in Figure 1.1. The cost-effectiveness analysis is described in Chapter 2, and the two surveys are described in Chapter 3. Chapter 4 contains a brief summary of the overall results of the project.

**Figure 1.1 – POLSSS Project Activities and their Inter-relationships**
2. The Cost-Effectiveness Analysis

2.1 Overview of Analytical Framework

The cost-effectiveness analysis was performed using a structured approach developed at RAND to assist policymakers in evaluating public policy options in situations involving complex systems with multiple measures of performance and involving competing interest groups with different, and frequently conflicting, goals. In the context of maritime navigation and safety in the North Sea and areas around Dutch seaports and approaches, there are a wide variety of individual traffic management instruments and measures that could be implemented (see Sec. 2.2). We call a change in the existing set of traffic management instruments and measures a tactic. Each tactic, alone or in combination with other tactics (we call a combination of tactics a strategy), will affect the occurrence or the severity of traffic accidents or mitigate their negative consequences (e.g., tactics related to search and rescue services). The accidents have many different types of effects, including effects on safety, the environment, and the economy. The tactics also have effects that are not related to accidents. For example, changes in routing may cause extra sea miles that introduce costs. The tactics also introduce financial costs. We use the term impacts to refer to the effects that result from the implementation of a tactic. Performance measures (in natural units, such as cubic meters of oil spilled) are defined for each of the impacts of interest (see Sec. 2.3). One of the major tasks in the cost-effectiveness analysis was to estimate the effects of the tactics on the performance measures.

The impacts of tactics are estimated for a variety of different types of accidents, including collisions, contacts, strandings, and some foundering (see Sec. 2.1.2). In addition to the type of accident, the consequences of an accident depend on the types of ships that are involved (e.g., ferries and oil tankers). The analysis is primarily focused on the annual cumulative effect of all accidents. However, some types of accidents happen rarely but have large consequences. We call these accidents disasters. The impacts of the tactics are likely to differ by type of disaster. Because of the magnitude of their consequences, we analyze each of a number of different types of disasters, called scenarios, separately (see Sec. 2.1.2). An example of a scenario studied in detail is a ferry colliding with an oil tanker.

The results of the "impact assessment" (the impacts of tactics) are presented in the form of tables called scorecards (see Sec. 2.5). Each row of a scorecard represents an impact and each column represents a tactic. An entire column shows all of the impacts of a single tactic; an entire row shows each tactic'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. The POLSSS study analyzes different regions separately (see Sec. 2.1.3). Because most of the tactics apply to some regions and not to others, and the impacts of the tactics differ by region, there are separate scorecards for each region. There are also scorecards showing the impacts of each tactic over the regions.
Since we are concerned with assessing the impacts of tactics and strategies under future conditions, it is important to define what those conditions might be. We call the set of assumptions about the external conditions within which the tactics will be operating the context. Context variables (which remain fixed throughout the analysis) include such things as the traffic intensities, the types and sizes of ships, the quality of the vessels, and the level of training of the crews. The entire analysis was conducted separately for two different contexts (see Sec. 2.6). The first set of context variables describes the situation from the present up to the year 2003. The second set of assumptions is used to describe the situation within the time period 2004-2010.

2.1.1 The Sea Shipping Safety System

The first step in a policy analysis study is to define the system of interest. This means (1) defining the boundaries of the system (identifying what is inside and what is outside of the system), (2) defining the structure of the system (the elements inside the system, and their relationships), and (3) defining the output of the system (the impacts of interest). In our case, the system is the Dutch maritime traffic system, which was defined to include all commercial shipping that takes place within the Dutch Continental Shelf of the North Sea, Dutch coastal waters, harbor approaches, and estuaries. The analysis focused on commercial vessels. Recreational vessels were not an integral part of the analysis. However, we made remarks concerning recreational vessels whenever they played a crucial role.

In order to define the structure of the system we developed a system diagram, which is a graphical representation of the system being studied. In a large and complex system like the maritime traffic system, there are a large number of interrelated elements, activities, and subsystems. A system diagram cannot usefully represent everything within the system, and should not try to do so. The system diagram is a tool that is used to think systematically about how the current system can change in the future, and how these changes might affect the performance measures of interest to the project. Thus, it focuses on only those aspects of the system that are likely to have an important effect on these performance measures.

Figure 2.1 shows the system diagram for the maritime traffic system. There are four types of elements within the system:

1. Physical characteristics -- aspects outside the control of any authorities, such as weather, sea depths, and currents, and the controllable characteristics of sea areas that can be considered to be fixed, such as the Maasvlakte or dredging.

2. Ship characteristics -- the quality of the ships, the equipment on board, and the capabilities of the crew.

3. Traffic flows -- numbers and types of ships and their cargoes.

4. Traffic management instruments -- the combination of individual instruments and subsystems that help ensure efficient, safe movement of traffic through the physical system.
There are elements of the system that are not controllable by the government, elements outside the system that affect the system, and controllable elements that we consider fixed in the analysis. All three of these types of elements are considered as the context for the analysis, and remain fixed throughout the analysis. Most of the controllable elements are changes to traffic management system. Tactics are possible changes to the system that are controllable by the Dutch government and that we are considering within the POLSSS project.

For the POLSSS project, the primary outputs of interest from this system are accidents (which we also call casualties). Traffic management measures are designed to prevent accidents. The tactics analyzed in the project affect the number and type of accidents. The extent to which they affect accidents depends on the characteristics of the future system – the system’s physical characteristics, traffic flows, traffic management system, and ship characteristics. Since the cost-effectiveness analysis examined only tactics related to traffic management, we
limited ourselves to accidents that can be affected by the traffic management system. The accidents themselves result in a range of consequences that are of interest for the cost-effectiveness analysis. They are directly dependent on the type of accident and on the instruments that are used after the accident has occurred (the search and rescue (SAR) and contingency planning instruments).

2.1.2 Types of Accidents

The traffic management system focuses on preventing accidents involving commercial vessels. However, some types of accidents can not be prevented by traffic management instruments. Since the cost-effectiveness analysis was designed to evaluate the impacts of implementing traffic management tactics, it excluded accidents that would not be prevented by the tactics. Thus, the analysis includes collisions, contacts, and strandings where professional vessels are involved. Accidents that involve only recreational vessels are excluded. Foundering is included only when estimating the consequences of accidents involving ferries, because this type of accident is the primary contributor to the probability of a fatality. Since traffic management tactics do not affect accidents that happen because of problems on ships, such as fires and explosions or spontaneous hull failures, these accidents were excluded from the analysis.

The accidents that are studied in POLSSS cover about 80% of all the sea shipping accidents in the study area (see Table 2.2). We estimated the annual cumulative effect of the accidents included in the POLSSS study. This formed our base case against which the impacts of changes in the traffic management system were compared.

We also estimated the effect from accidents that happen rarely but have large consequences. We call these accidents disasters (rampen). The consequences of disasters depend on the types of ships that are involved (e.g., ferries or oil tankers). Also, the impacts of the tactics are likely to differ by the type of disaster. Because of the magnitude of their consequences, we analyzed a number of different types of disasters, called scenarios, separately. The total number of possible disasters is so large that all the disasters could not be analyzed within this project. Only some of the disasters were examined closely. Scenarios were excluded if their impacts were expected to be small or if they were expected to happen extremely rarely. The following seven scenarios were analyzed in detail:

1. Ferry foundering or colliding with a ship
2. Ferry colliding with an oil tanker or chemical tanker (a subset of Scenario 1)
3. Chemical tanker colliding with a ship
4. Oil tanker colliding with a ship
5. Gas tanker colliding with a ship
6. Ship colliding with a platform
7. Ship having a serious accident at a harbor entrance (thus blocking the port)
2.1.3 Regions

We defined the system to include all commercial shipping that takes place within the Dutch Continental Shelf of the North Sea and the Dutch coastal waters, harbor approaches, and estuaries. This area was divided into four categories, some of which were further subdivided. The criteria that were used to define sensible boundaries for the regions were:

- Traffic characteristics of the regions (e.g., density of the vessels)
- Physical characteristics of the regions
- Legal definitions of the region (e.g., boundaries of coastal waters and Dutch Continental Shelf)
- Borders of the regional nautical authorities.

The resulting set of four categories and ten analysis regions are (see Figure 2.2):

1. Open sea
2. Coastal waters
3. Harbor approaches
   a) Small harbor approaches
   b) Amsterdam/outside
   c) Amsterdam/inside
   d) Rotterdam/outside
   e) Rotterdam/inside
   f) Approach Westerschelde
4. Estuaries
   a) Waddenzee
   b) Westerschelde (East of Vlissingen, Gent–Terneuzen Kanaal is included)

![Figure 2.2 - The POLSSS Regions](image-url)
Traffic intensity and the number and distribution of accidents by type vary greatly by region. Table 2.1 shows the average number of vessels present at any one time by regions. Table 2.2 shows the percentage distributions of the different types of sea shipping and inland shipping accidents for each of the POLSSS regions. Figure 2.3 shows the distribution of the total number of accidents across the regions.

Table 2.1 – Estimated Average Numbers of Vessels Present at Any One Time (by POLSSS Region)

<table>
<thead>
<tr>
<th>Region</th>
<th>All sea ships</th>
<th>Route committed sea ships</th>
<th>Non route committed sea ships</th>
<th>Inland vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Sea</td>
<td>234</td>
<td>129</td>
<td>104</td>
<td>0</td>
</tr>
<tr>
<td>Coastal</td>
<td>33</td>
<td>4</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>Amsterdam / outside</td>
<td>15</td>
<td>4</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Amsterdam / inside</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Rotterdam / outside</td>
<td>38</td>
<td>22</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Rotterdam / inside</td>
<td>31</td>
<td>-</td>
<td>-</td>
<td>52</td>
</tr>
<tr>
<td>Approach Westerschelde</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Small harbor approaches</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Waddenzee</td>
<td>11</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Westerschelde / East</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: MANS traffic database year 2000

Table 2.2 – The Yearly Distribution of Accidents by Type for Each Region

<table>
<thead>
<tr>
<th>Type of an accident (Sea shipping and inland vessels)</th>
<th>NCP</th>
<th>Rotterdam</th>
<th>Amsterdam (Noordzeekanaal)</th>
<th>Waddenzee</th>
<th>Westerschelde</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collisions (samarvingen)</td>
<td>44%</td>
<td>42%</td>
<td>35%</td>
<td>33%</td>
<td>22%</td>
</tr>
<tr>
<td>Contacts (contacteren)</td>
<td>6%</td>
<td>34%</td>
<td>52%</td>
<td>19%</td>
<td>27%</td>
</tr>
<tr>
<td>Strandings (stranden)</td>
<td>17%</td>
<td>5%</td>
<td>3%</td>
<td>20%</td>
<td>31%</td>
</tr>
<tr>
<td>Founderingen</td>
<td>17%</td>
<td>2%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>16%</td>
<td>17%</td>
<td>9%</td>
<td>23%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Source: [Stekelenburg and Gelbach, 1996], [Helms, 1996]

1 The source reports do not use exactly the same definitions for regions as those used in the POLSSS project; thus the distribution of accidents over the regions is approximate. The regions “Rotterdam”, “Noordzeekanaal” and “Westerschelde” cover approximately “Rotterdam/Inside”, “Amsterdam/Inside” and “Westerschelde” POLSSS regions, respectively. Figure 2.3 also includes accidents that were not included in the cost-effectiveness analysis.
2.2 Tactics

A tactic is a single action taken to affect the maritime traffic system, such as widening the shipping lanes in the open sea by a certain percentage or removing all of the buoys used as reference marks. One way of characterizing tactics is by their mechanisms, or the ways they operate. This gives rise to the following nine groups of tactics:

1. **Routing tactics**, which affect traffic separation schemes and deep water routes. They assign different shipping and offshore activities to different parts of the sea based on sailing direction, vessel size, and type or function.

2. **Position fixing tactics**, which affect a variety of radio navigation systems that provide great accuracy in identifying ship positions.

3. **Waterway marking tactics**, which refer to local (often visual) navigation aids that include fixed or floating lighted and unlighted objects (buoys and beacons), radar beacons of different types, and fixed land markings (e.g., lighthouses).

4. **Information supply tactics**, which refer to the provision of traffic, hydrological, and other information to ships. This category includes the transmission of static information (such as nautical charts and publications) and dynamic information (such as weather forecasts).

5. **Piloting tactics** are changes to the use of persons who help guide ships through the Dutch part of the North Sea and the approach areas to Dutch seaports, on board as well as from shore.

6. **Vessel traffic services (VTS) tactics**, which affect the collection of information related to shipping traffic in port areas and the distribution of this information interactively to ships, pilots, and/or other officials. The main components of the VTS are manned traffic centers, radar tracking systems, communication systems, and data handling systems.
7. **Search and rescue service (SAR) tactics**, which refer to actions that are taken after an accident has occurred, in order to limit the negative effects of the accident, including the preparation of such actions.

8. **Contingency planning tactics**, which refer to plans that are developed in case a serious accident occurs. These plans deal with such things as the operational coordination of the handling of response equipment.

9. **Legislation and administration tactics**, which affect the rules that are intended to regulate traffic behavior. Such rules are the International Regulations for preventing collisions at sea (COLREGS), the Shipping Traffic Act incorporated for the Dutch Waters, the Shipping Regulations Territorial Waters, and the traffic rules in inland waterways.

### 2.3 Impacts

As mentioned before, the tactics have a range of impacts. They affect the number or severity of accidents, either reducing or increasing the risk. The accidents themselves have further consequences, such as environmental and economic impacts. Some of the tactics affect routing -- resulting in changes in sailing miles. We identified six categories of impacts to be included in the analysis. Within each impact category, we identified impacts that we would use to measure the performance of the tactics. For safety and some environmental consequences, the impacts from disasters were analyzed separately. Table 2.3 lists the categories and specific impacts we used. The models and methods used to estimate the various impacts are described in [Walker et al., 1998a].
Table 2.3 – Impacts Used in the Analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Impacts</th>
</tr>
</thead>
</table>
| Impacts on safety       | • Number of accidents  
                          • Internal individual risk over all traffic accidents (probability of a person dying per traveled kilometer) |
| Impacts on the environment | • Oil spills from accidents (total cumulative amount per year)  
                          • Chemical spills (probabilities for Ecological Risk Indicator)  
                          • Amount of oil on coast (total cumulative amount per year)  
                          • Total number of birds threatened by oil  
                          • Operational CO₂ emission caused by the use of tactic (total cumulative amount per year)  
                          • Operational oil spills caused by the use of tactic (total cumulative amount per year) |
| Economic impacts        | • Loss of income to shipping companies (the immobilization costs during the period of repairing)  
                          • Repair costs  
                          • Cleaning costs (for all the accidents)  
                          • Extra sea miles caused by the use of a tactic: sailing costs  
                          • Delay costs caused by tactics |
| Impacts from disasters  | Ferry – Ship disaster, or foundering ferry:  
                          • Individual risk (probability of a person dying per traveled kilometer)  
                          • Societal risk (probabilities per year of more than 10, 30, and 100 deaths in one disaster)  
                          Ferry – Oil/Chemical tanker disasters:  
                          • Individual risk (probability of a person dying per traveled kilometer)  
                          • Societal risk (probabilities per year of more than 10, 30, and 100 deaths in one disaster)  
                          Chemical/gas tanker – Ship disaster:  
                          • Individual risk (the area within which the probability of a person dying is more than one per million)  
                          • Societal risk (probabilities per year of more than 10, 30, and 100 deaths in one disaster)  
                          Oil tanker – Ship disaster:  
                          • Cleaning costs (expected costs per year from a disaster)  
                          • Large oil spill (probabilities per year of oil spills more than 30000 m³ and 100000 m³)  
                          • Amount of oil on coast  
                          • Number of birds threatened by oil  
                          Ship – Platform disaster:  
                          • Individual risk (probability per year that a person on platform dies)  
                          • Societal risk (probabilities per year of more than 10 and 30 deaths in one disaster)  
                          Ship – Harbor entrance:  
                          • Economic consequences (delay costs) |
| Other impacts           | • Stakeholder acceptance (tactic is practical and effective)  
                          Financial costs                                                                 |
| Financial costs         | • Investment costs (except for piloting tactics)  
                          • Operating costs (except for piloting tactics)  
                          • The number of piloted trips that are affected by a tactic (piloting tactics)  
                          • Change in man-hours (piloting tactics)  
                          • Change in sea miles of pilot tenders (piloting tactics) |
2.4 Contexts

Since we are concerned with assessing the impacts of tactics under future conditions, it is important to define what those conditions might be. In analyzing the current situation as the base case, we also have to be specific about the assumptions we are using. We call the set of assumptions about the external conditions within which the tactics will be operating the context. The analysis was carried out for two sets of assumptions about the external conditions:

1. the current situation (assumed to be the case through 2003)
2. the future situation (assumed to be the case from 2004 through 2010).

The context variables (which remain fixed throughout the analysis) are the elements of, and inputs to, the maritime traffic system (see Fig. 2.1), excluding the tactics themselves. They include such things as the traffic demands, types and sizes of ships, and crew quality, as well as assumptions about the traffic management measures that will remain fixed throughout the analysis (i.e., that will not be evaluated as tactics). Many of the context variables are beyond the control of the Dutch government. For example, we are not able to stipulate what the traffic intensity will be; we can only make assumptions about what it will be. Some of the context variables may not yet be part of the system, but may play a crucial role in the future. Examples are possible changes in international laws. The most important set of assumptions is related to the implementation and effectiveness of traffic management measures. For the current situation, we specified the existing traffic management measures and how they are being used. For the future situation, we had to clearly define the changes in the context and how they would be assumed to work. For example, if the future context assumes there will be new equipment on a ship, we had to make assumptions about how the equipment would be used, and how effective it would be. Some of the tactics generated during the project were treated as context variables.

There are four sets of assumptions that we had to define for each time period:

1. Assumptions about traffic demand (traffic intensity and traffic mix).
2. Assumptions about traffic management measures, including routing, VTS, and regulations that were to remain fixed throughout the analysis. This set includes assumptions about legislation (especially international laws).
3. Assumptions about the characteristics of the vessels (including assumptions about ship quality (equipment on board) and crew quality).
4. Assumptions about the characteristics of the analysis regions.

Tables 2.4 and 2.5 summarize the assumptions we made about the first three categories of context variables for the two time periods. The effects of these context variables form our base case; the impacts of tactics are evaluated relative to this base case.
Table 2.4 – Context Variables for Time Period 1998 – 2003

<table>
<thead>
<tr>
<th>Context variable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Traffic intensity and mix</td>
<td></td>
</tr>
<tr>
<td>• MANS revised traffic database for 1995.</td>
<td></td>
</tr>
<tr>
<td>• Data from the year 2000 are used.</td>
<td></td>
</tr>
<tr>
<td>2. Traffic management measures</td>
<td></td>
</tr>
<tr>
<td>• Current traffic management measures</td>
<td></td>
</tr>
<tr>
<td>• All vessels at harbor approaches are assisted by VTS</td>
<td></td>
</tr>
<tr>
<td>3. Quality of vessels</td>
<td></td>
</tr>
<tr>
<td>• The quality of vessels will be improved compared to the current situation.</td>
<td></td>
</tr>
<tr>
<td>• All vessels (excluding recreational vessels) have radar and GPS</td>
<td></td>
</tr>
<tr>
<td>• 25% of vessels have transponders</td>
<td></td>
</tr>
<tr>
<td>• On-shore equipment necessary for transponders exists</td>
<td></td>
</tr>
<tr>
<td>• 15% of vessels are “sub-standard”</td>
<td></td>
</tr>
<tr>
<td>• Procedures for “ship domain approach” are in place.</td>
<td></td>
</tr>
<tr>
<td>4. Characteristics of the analysis regions</td>
<td></td>
</tr>
<tr>
<td>• No Maasvlakte 2 will be built</td>
<td></td>
</tr>
<tr>
<td>• The locks of Ijmuiden will not be improved</td>
<td></td>
</tr>
<tr>
<td>• The Westerschelde area will not be deepened</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.5 – Context Variables for Time Period 2004 – 2010

<table>
<thead>
<tr>
<th>Context variable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Traffic intensity and mix</td>
<td></td>
</tr>
<tr>
<td>• MANS revised traffic database for 2010</td>
<td></td>
</tr>
<tr>
<td>• Data from the year 2007 are used.</td>
<td></td>
</tr>
<tr>
<td>2. Traffic management instruments</td>
<td></td>
</tr>
<tr>
<td>• The traffic management instruments are the ones used in the 1998-2003 context, with changes described below.</td>
<td></td>
</tr>
<tr>
<td>• There are central points of distribution of information in each region.</td>
<td></td>
</tr>
<tr>
<td>• There is international standardization of external data transmission in combination with EDI selection programs on board.</td>
<td></td>
</tr>
<tr>
<td>• Special collision regulation for high speed craft.</td>
<td></td>
</tr>
<tr>
<td>• Modification of the regulations concerning collision avoidance at sea (COLREGS)</td>
<td></td>
</tr>
<tr>
<td>• Obligation to follow the routings for all vessels.</td>
<td></td>
</tr>
<tr>
<td>• Procedures for “ship domain approach” are in place.</td>
<td></td>
</tr>
<tr>
<td>3. Quality of vessels</td>
<td></td>
</tr>
<tr>
<td>• The quality of vessels will be improved compared to the situation assumed for 1998-2003.</td>
<td></td>
</tr>
<tr>
<td>• All ships (excluding recreational vessels) have transponders</td>
<td></td>
</tr>
<tr>
<td>• Require multiple position fixing systems (PFS) on board for backup.</td>
<td></td>
</tr>
<tr>
<td>• Communication through transponders as part of ship-ship position fixing and identification.</td>
<td></td>
</tr>
<tr>
<td>• All the vessels which travel in the North Sea (including fishing vessels and excluding recreational vessels) have DGPS and ECDIS (Electronic Charts Display Information System)</td>
<td></td>
</tr>
<tr>
<td>• EDI selection programs on board</td>
<td></td>
</tr>
<tr>
<td>• The proportion of “sub-standard” ships is the same as in time period 1998 – 2003; i.e. 15% of the vessels are “sub-standard”.</td>
<td></td>
</tr>
<tr>
<td>4. Characteristics of the analysis regions</td>
<td></td>
</tr>
<tr>
<td>• No Maasvlakte 2 will be built</td>
<td></td>
</tr>
<tr>
<td>• The locks of Ijmuiden will not be improved</td>
<td></td>
</tr>
<tr>
<td>• The Westerschelde area will not be deepened</td>
<td></td>
</tr>
</tbody>
</table>
2.5 Estimating the Impacts

The impacts of a tactic on safety, the environment, and the economy can be viewed as being produced in a two-step process. First, the tactic changes the number of accidents (a tactic affects the casualty rate of vessels – the rate at which accidents occur). The accidents then produce the impacts of interest. Figure 2.4 shows this chain of events (and the models that were used to estimate them). Tactics in categories 2, 4, and 9 were treated in a different way. They were included in the context (see Sec. 2.4), and are, therefore, not shown in Fig. 2.4.

![Diagram of the estimation process]

**Figure 2.4** – The Estimation of the Safety, Environmental, and Economic Impacts of Tactics in Regions Covered by MANS.

As shown in Fig. 2.4, the impacts of a tactic are the direct results of changes in traffic intensity, traffic composition, use of routes by the traffic, and casualty rates. Changes in the first three traffic items come directly from the specification of contexts and tactics. However, we needed experts\(^2\) to help us estimate the changes in casualty rates that could be expected.

---

\(^2\) We use the term “expert” to refer to a person who provided us with detailed information about changes in casualty rates or probabilities in event trees that were used in estimating the impacts of tactics. We use the term “stakeholder” to refer to a member of one of the various groups of people who are directly related to professional maritime activities or who may suffer from the consequences of maritime accidents. This term is used when we describe stakeholder opinions concerning the impacts of tactics or the safety situation.
from the implementation of a tactic. In order to avoid biased estimates caused by professional connections to certain tactics, we selected a large and balanced group of experts for each of the tactic categories. We briefly describe the approach we used to obtain these estimates for each of the tactic categories.

**Routing, fairway marking, pilotage/VTS tactics.** We held one-day meetings of experts to estimate casualty rates for each of these three sets of tactics. In the case of routing tactics, the experts estimated changes in casualty rates for only one of the tactics. (The effects on accidents from other tactics in this category were able to be estimated by MANS from the other inputs to the model.) Each of the other meetings had the same format. First, we gave the information about the tactics to be considered and the context for the two periods. Next, each expert was asked to provide estimates of relative percentage changes in casualty rates if a certain tactic were implemented. For each tactic, we asked for changes in casualty rates for different users (small vessels, large vessels, fishing vessels, inland vessels, and recreation vessels), different regions, different context variables, and different environmental conditions (normal conditions, storm and bad visibility). For each tactic, the full set of casualty rate changes was estimated by each expert for two types of accidents (collisions and groundings) for the two time periods being analyzed (1998-2003 and 2004-2010).

**SAR-tactics.** The SAR-activity for most accidents at sea involves very few people at risk. However, when a ferry founders or is involved in a serious collision with a ship, many passengers are likely to end up in the water. The worst type of collision would be if the other ship is a tanker, since an explosion or serious fire might follow the collision. Such disasters have not happened in Dutch waters. However, when making policy for safety one needs to have some idea of the consequences from such a disaster. We know the probability of a collision with a ferry, but do not know rescue probabilities. We estimated the probabilities of what happens after such a disaster by using an event tree. The tree begins with a collision. From this point, the tree branches with succeeding events, and ends with a number of people that would drown in the absence of SAR activities. The meeting with experts about SAR tactics was divided into two parts. In the first part, we had a general discussion to reach a consensus on each of the probabilities of the tree. Whenever possible, the experts’ opinions were checked against other sources. In the second part of the meeting, each expert was asked individually to assign three values to each end point of the event tree: the number of passengers that would end up in the water, the number of passengers that would be rescued by current SAR procedures, and the number of deaths. Separate event trees were developed for different sizes of ferries, for collisions occurring in deep and shallow water, and for collisions occurring during the day and at night. A simple event tree is used for the Ship – Platform disaster. We assumed that a platform collapses when the colliding energy is above a certain value. When this happens, we assumed that the whole platform crew ends in the water.

The casualty rates, traffic intensities, and routing information are the major inputs to the MANS model. The MANS model then uses the historical data in its database to estimate the change in the number of accidents that are expected to occur due to the implementation of the tactic (i.e., due to the change in casualty rates) [van der Tak and Glansdorp, 1995]. Knowing the numbers and types of accidents, the safety, environmental, and economic impacts can be estimated, as follows:
• **Safety impacts**. For estimating the safety impacts, the output of MANS is fed into event tree models for each type of accidents. These event trees are defined for ferry and platform accidents. These models produce estimates of individual and societal risk for tactics in Categories 1, 3, 5, and 6. However, tactics in Categories 7 and 8 change the individual and societal risk. New models were developed for this project to estimate the impacts of tactics in these categories.

• **Environmental impacts**. MANS models produce estimates of the chemical spills and oil spills that are expected to result from accidents. Also, the amount of oil on the coast and the number of birds threatened by oil are directly available from the models. A new model was built for this project that estimates the ecological damage caused by chemical spills. The degree of damage is described with an Ecological Risk Indicator that takes on values from 1 (negligible ecological damage) to 5 (very large ecological damage).

• **Economic impacts**. Information from DGG reports was available to estimate the costs of extra sea miles traveled (sailing costs for each sea mile) and the costs of cleaning oil (the cost for each ton of oil cleaned) once the number and type of accidents are known. We used information from other sources to estimate repair costs, delay costs, and loss of income caused by accidents.

• **Impacts from disasters**. Depending on the disaster, a subset of impacts of interest was defined. These impacts related to safety, environment, and economic were estimated for disasters in the same way as for other accidents as described above.

It should be noted that the model outputs described above were not available for all of the regions of interest. The MANS model does not cover the inside part of the harbor approaches or estuaries (the Westerschelde and Waddenzee). For those regions not covered by MANS, we estimated the changes in the number of accidents and the consequences of accidents using information in reports, to the extent that such information was available. Based on this information, we developed simple models to estimate the impacts.

• **Stakeholder acceptance**. The results from two surveys conducted in the second part of the POLSSS project were used to qualitatively describe the stakeholders’ acceptance of tactics. The surveys and the results are summarized in Chapter 3. Not all of the tactics were included in the survey. For those tactics not included, we used expert opinions to represent stakeholder acceptance.

• **Financial costs**. The implementation of a tactic introduces financial costs. These costs were divided into investment costs and operating costs. The analysis focused on the total costs of implementing a tactic, taking into account costs to the government, to the users, and to other organizations (e.g., piloting organizations). We calculated the changes in the total costs caused by the use of tactics, but we did not specify who pays. For example, with tactics related to VTS we considered the total change in costs, but did not specify how changes in costs affect the fees paid by users.
2.6 Presenting the 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\(^3\). Decisionmakers then use this aggregate measure to compare alternatives.

In POLSSS, we used a disaggregate approach that presents a column of impacts for each tactic, with each impact expressed in natural units. 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, we have described some effects in monetary terms and others in physical units; some were assessed with quantitative estimates (e.g., individual risks and air pollutant emissions), and others with qualitative comparisons (e.g., "the stakeholder acceptability for this tactic is high").

A disadvantage of this approach is that the amount of detail can make it difficult for the decisionmakers to see patterns or draw conclusions. This is a particular problem in POLSSS, since the analysis of tactics was carried out separately for each POLSSS region. To aid decisionmakers in recognizing patterns and trading off disparate impacts, we used a display device called a scorecard. Impact values are summarized (in natural units) in a table, each row representing one impact and each column representing a tactic. An entire column shows all of the impacts of a single tactic; an entire row shows each tactic’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. Impact values can then be ranked across columns, for each row independently of all other rows. Tradeoffs among impacts can then be made by making comparisons between rows. An example of the resulting scorecard is presented in Appendix B. We generated separate scorecards for each region, in which case the columns are the different tactics affecting that region (regional scorecard), and for each tactic, in which case the columns are the different regions (tactic scorecard). The regional scorecards are presented in Appendix D of [Walker et al., 1998a] and the tactics scorecards are presented in [Walker et al., 1998b].

\(^3\) For a discussion of some of these approaches, see [Keeney and Raiffa, 1993].
2.7 Results from the Analysis of Tactics

A key step in the policy analysis process is identifying possibilities for making changes in the system being studied. Considering the general maritime safety system, there are a wide variety of individual policy options (which we call tactics) that could be implemented and that might contribute to meeting future goals or targets. This section describes each of the tactics whose impacts were assessed, and provides a summary of the results of that assessment.

The analysis started with a set of 78 tactics. This set was reduced through a series of steps to produce a set of 30 tactics that were analyzed in detail. We used the following criteria to identify tactics that would not be analyzed in detail:

A. The tactic is not a traffic management measure.
B. The tactic is part of another tactic.
C. The tactic is not internationally feasible within 10 years.
D. The tactic is not implementable.
E. The effects of the tactic are not able to be measured.
F. The tactic's description is vague or unclear.

Detailed impacts of the remaining 30 tactics were assessed, and the results were presented in scorecards. These tactics and the regions they affect are listed in Table 2.6. Brief descriptions of all 30 tactics and the results of their evaluation are presented in this section. Detailed descriptions of the tactics are given in a separate volume [Walker et al., 1998b].

We identified promising tactics among the 30 tactics. A tactic was said to be promising if it was found to lead to an increase in safety (no matter how small) and/or a decrease in monetary costs (financial costs plus economic costs). We did not make tradeoffs between financial costs and safety; such tradeoffs are in the policymakers' domain. However, we did compare the change in the direct economic consequences from accidents that a tactic would produce with its financial costs. A tactic was not considered to be promising if its financial savings were estimated to be less than the resulting increase in economic consequences from accidents.

The results presented in this section should be considered screening results. The analysis started with a large number of tactics and produced a small set of promising tactics. The set of promising tactics should now be subjected to more detailed analysis – including checks on feasibility, costs, and the underlying assumptions that were used in the analysis. After that, weights can be assigned to the different impacts in order to determine preferences among the tactics.
Table 2.6 – Tactics in the Cost-Effectiveness Analysis and the Regions They Affect

<table>
<thead>
<tr>
<th>Tactic category</th>
<th>Tactic</th>
<th>Open Sea</th>
<th>Coastal waters</th>
<th>Amsterdam / outside</th>
<th>Rotterdam / outside</th>
<th>Rotterdam / inside</th>
<th>Approaches</th>
<th>Small ship approaches</th>
<th>Waddenzee</th>
<th>Westerschelde / East</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Routing</td>
<td>L.1.1</td>
<td>Implement a new TSS to Westerschelde.</td>
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<tr>
<td></td>
<td>L.1.4</td>
<td>Implement a new TSS between Maas west inner and Maas west outer</td>
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<tr>
<td></td>
<td>L.1.6</td>
<td>Vessels carrying dangerous goods in bulk are not allowed to use the Oostgat channel.</td>
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<tr>
<td></td>
<td>L.2.5</td>
<td>No fishing or recreational vessels are allowed in TSSs. Combined with mandatory cross-over areas, entrance to, and exits from lanes.</td>
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<tr>
<td></td>
<td>L.3.3</td>
<td>Use different lanes for different types of ships.</td>
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<tr>
<td></td>
<td>L.3.4</td>
<td>Widening of lanes by 20%.</td>
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<tr>
<td>3. Waterway marking</td>
<td>L.6.6</td>
<td>50% of buoys with a light are replaced by buoys without a light</td>
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<tr>
<td></td>
<td>L.6.1</td>
<td>50% of buoys with a light are replaced by buoys without a light</td>
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<tr>
<td></td>
<td>3.2.1A</td>
<td>Remove 50% of the buoys used as reference marks</td>
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<tr>
<td></td>
<td>3.2.1B</td>
<td>Remove all the buoys used as reference marks</td>
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<tr>
<td></td>
<td>L.2.6</td>
<td>Shut down nine lighthouses</td>
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<tr>
<td>5. Piloting and VTS</td>
<td>L.5.1</td>
<td>Implement &quot;Tailor-made Pilotage&quot; (Give more authority to VTS operators)</td>
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<td></td>
<td>L.5.2</td>
<td>All vessels are piloted by remote pilotage (excluding vessels carrying hazardous goods)</td>
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<td></td>
<td>L.5.2.1</td>
<td>Make deep-sea pilotage required for 'sub-standard' ships</td>
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<td></td>
<td>L.5.2.2</td>
<td>Make deep-sea pilotage required for vessels carrying hazardous goods</td>
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<td></td>
<td>L.5.3</td>
<td>Use English as official communication language.</td>
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<tr>
<td></td>
<td>L.6.1</td>
<td>Ship domain approach is used when vessels enter or leave harbors</td>
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<td></td>
<td>L.6.2.3</td>
<td>Require transponder on board for ship-to-shore data communication</td>
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<td></td>
<td>L.6.3</td>
<td>Elaborate the concept of VTMS.</td>
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<tr>
<td>7. SAR</td>
<td>L.7.1A</td>
<td>Add helicopter to double existing capacity</td>
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<td></td>
<td>L.7.1B</td>
<td>Replace helicopter by one with double the existing capacity</td>
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<td></td>
<td>L.7.1C</td>
<td>Replace helicopter by two with triple the existing capacity</td>
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<td></td>
<td>L.7.2</td>
<td>Maintain information on positions of all suitable helicopters</td>
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<td></td>
<td>L.7.2.1</td>
<td>Locate helicopter on platform in North Sea</td>
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<td></td>
<td>L.7.2.5</td>
<td>Make transponder information available at Coast Guard station</td>
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<td></td>
<td>L.7.2.8</td>
<td>Improve capability of platforms and emergency vessels to handle victims</td>
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<td>L.7.2.9</td>
<td>Add three Coast Guard vessels with helicopter platforms.</td>
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<td></td>
<td>L.7.2.8</td>
<td>Decrease helicopter's notice time by keeping crew close to helicopter</td>
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<td></td>
<td>L.7.2.9</td>
<td>Add large rescue vessel with helicopter and SAR tender vessels</td>
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<tr>
<td>9. Contingency planning</td>
<td>L.8.3.1</td>
<td>Get rid of the salvage vessel (WAKER).</td>
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<td></td>
<td>L.8.3.2</td>
<td>Double the salvage vessel capacity</td>
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</tbody>
</table>

NOTE: Grey areas indicate that a tactic applies to these regions. * = the impacts for this tactic over all shaded regions are presented in the scorecard for this region

The first letter refers to the time period 1998-2003
The second letter refers to the time period 2004-2010

P = Promising
U = Unpromising
N = Tactic does not apply to the time period
X = Not applicable
2.7.1 Routing Tactics

All of these tactics are specific to a single region. For some tactics, their consequences for fishing vessels need further attention. Some promising tactics will be difficult to implement (e.g., widening of lanes by 20% requires that locations of anchoring areas and platforms need to be changed).

Tactic 1.1.1 Implement a new TSS to Westerschelde

**Specification:** The current traffic situation south of Vlissingen is not as safe as it could be. Tactic 1.1.1 is aimed at improving the situation. The tactic widens some of the current traffic separation schemes by moving some buoys to new locations. Some anchoring areas are redefined and their sizes decreased. Restrictions are introduced for some types of vessels with respect to their use of anchoring places. One place for pilots to board vessels is changed. The tactic would be implemented in two phases over a five-year period.

**Analysis:** This tactic is designed to reduce Social Risk. Its objective is achieved. The land area within the $10^6$ individual risk contour is decreased by 31%, and the Societal Risk probabilities are reduced by 17%. A change in anchoring policy (to move anchored vessels away from the shipping lanes) would improve the safety benefits from this tactic. The financial costs of the tactic are small. Stakeholders' acceptance is high except among pilots.

This tactic is promising.

Tactic 1.1.4: Implement a new TSS between Maaswest Inner and Maaswest Outer

**Specification:** This tactic defines a new north–south TSS between Maaswest inner and Maaswest outer for traffic crossing from and to the Westerschelde to improve safety. The crossing area would be marked by one cardinal buoy that would indicate directions for the traffic.

**Analysis:** This tactic introduces more sea miles to be sailed in the Rotterdam/outside region and decreases slightly the sea miles that vessels need to sail at Approach to the Westerschelde. The costs of the extra sea miles are 0.722 MNLG, while only 0.051 MNLG is gained back by a decrease in the number of accidents. All other impacts are less than 1%. Stakeholder acceptance is high, although the experts thought that the tactic would not be effective.

This tactic is promising because it has some positive impacts on safety. However, these impacts are small compared to costs introduced by extra sea miles.

Tactic 1.2.1: Vessels carrying hazardous goods in bulk are not allowed to use the Oostgat channel

**Specification:** The Oostgat channel is a shortcut for approaching the Westerschelde from the north. This tactic would prevent some vessels from using the shortcut. These vessels would need to take a longer route to enter the Westerschelde. Thus, the tactic introduces an extra cost -- additional sea miles -- for some vessels. The tactic aims to decrease the risk of

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4 Million Netherlands guilders
chemical/gas tanker disasters in the Oostgat channel, and thus to decrease the societal risk of people living along its shore.

Analysis: The impacts of this tactic were assessed by rerouting the ships with potential dangerous goods on board through the Wielingen. The impacts could not only be assessed for the “Approach to the Westerschelde”, because the route length within this region decreases, while the increase in other regions (Open Sea) is much more. Therefore the impacts of all regions are summarized and assigned to the “Approach to the Westerschelde”.

The total shipping costs of the extra nautical miles traveled are 9.1 MNLG.

Stakeholder acceptance of the tactic is high except among pilots.

This tactic has an impact on the location of the risk isocontours, but it is hard to assess, because the MANS-model and the model for the assessment of risk isocontours are not integrated/connected with each other in the regions where this tactic affects. The Individual Risk of $10^{-6}$ contour near the Oostgat lies in the water. Therefore it is not expected that this will give a real improvement in the critical situation near Vlissingen. Thus, taken together with the extra costs for shipping companies, this tactic is unpromising.

Tactic 1.2.5 + 1.1.6 No fishing or recreation vessels in TSS and mandatory crossovers

Specification: This tactic forbids fishing in the shipping lanes and forbids recreational vessels to be in the lanes. The fishing vessels and recreational vessels would be required to use the crossover areas to cross a shipping lane. Two crossover areas would be established in the traffic separation schemes northwest of the Wadden Islands. Each crossover area would be marked with one buoy with a light, which would indicate the direction for traffic.

Analysis: The results show benefits for nearly all impacts. The direct saving on accident costs amounts to 1.5 MNLG and the implementation costs are negligible. The prohibition of fishing in a traffic lane provides the biggest contribution to the benefits of this tactic. However, the tactic causes extra costs for fishing vessels by introducing extra sea miles when they need to use mandatory crossover areas. A rough estimate of these costs was 2.8 MNLG under the assumption that fishing vessels do not change their fishing grounds.

The stakeholder acceptance of this tactic was very high. However, many stakeholders thought that the tactic would not be practical.

This tactic is promising. However, the extra costs to fishing vessels need to be further studied.

Tactic 1.3.3 Use different lanes for different types of ships

Specification: Separate lanes would be defined for vessels carrying hazardous goods. The tactic aims at reducing the number of accidents where vessels carrying hazardous goods are involved. This tactic would apply only to the approach to the Rotterdam harbor and to the open sea regions.

Analysis: The tactic makes sense only in the Traffic Separation Scheme Maas-West inner and Maas-West outer to Rotterdam. Since the Special Provisions came into force in 1997, all larger ships carrying dangerous goods are obliged to take the Deep Water Traffic Separation
Schemes. This means that the Traffic Separation Schemes Texel, Vlieland, and Terschelling only contain a few small vessels with dangerous goods. There is no need to allocate a part of the lane for this very low number of vessels.

A substantial part of the traffic in The Deep Water Route carries dangerous goods. It is necessary to give them as much space as possible. It is questionable if a division of this route into two parts would be a good solution, since the total width is already limited to 2 nm.

The scorecards for this tactic show a little increase in the total number of all accidents and the costs of these accidents. However, there is a decrease of 6% to 15% in the accidents, spills, and risk from ships carrying dangerous goods. Thus, the objective of this tactic to reduce accidents where vessels carrying dangerous goods are involved is achieved.

The stakeholder acceptance of this tactic is very low based on the expert opinions.

Although this is a promising tactic, it will be difficult to implement and has a low stakeholder acceptance.

**Tactic 1.3.4 Widening of lanes by 20%**

**Specification:** This tactic aims at giving vessels more space for maneuvering. This tactic would apply only to the approach to the Rotterdam harbor and to the open sea regions. All the TSSs there would be widened by 20%. The tactic would be implemented by moving some of the current markings to new locations.

**Analysis:** By widening the shipping lanes by 20% vessels, ships would have more room to navigate. However, in the present situation this tactic would bring the vessels in lanes closer to platforms and anchoring areas.

Initial results showed a decrease in collisions between sailing vessels, but an increase in the number of accidents with ships at anchor, platforms, piers, and strandings. This could be expected because, in our analysis, anchorage areas, platforms, piers, and stranding lines were not changed. Thus, these could be located within the new traffic lanes. For this reason, only the impact of the tactic on collisions between moving ships within the lanes was considered.

By only considering the impacts on collisions, the maximum benefits could be assessed. The total savings over all regions are 0.46 MNLG on direct accident costs. The financial costs of this tactic are low.

Stakeholder acceptance of the tactic is high based on expert opinions. However, oil companies most likely dislike the tactic because there will be less suitable areas for platforms.

The maximum benefits seem to be too small to justify a widening of the shipping lanes at the cost of less space for other activities. However, there are some positive impacts and so the tactic is promising. In any case, the tactic would require further (local) research before deciding whether it should be implemented.
2.7.2 Waterway Marking Tactics

These tactics are generally designed to reduce financial costs without reducing safety. The nature of the results for this category of tactics varies significantly by region. There are some promising tactics, but no general observations can be made. The promising tactics are:

Tactic 3.1.6 50% of buoys with a light are replaced by buoys without a light

**Specification:** There are currently 98 buoys with a light in the Waddenzee and 118 buoys with a light in the Westerschelde. So, implementation of this tactic would mean replacing 49 buoys with lights by non-light buoys in the Waddenzee and 59 in the Westerschelde. The tactic aims at reducing the financial costs.

**Analysis:** This tactic applies to the regions Approach Westerschelde, Westerschelde, and Waddenzee can implemented regionally. The increase in accidents is nearly 4% for all impacts in all three regions. The annual accident costs and annual financial savings (in MNLG) are:

- Approach Westerschelde: increased accident costs are 0.27 MNLG and financial savings are 0.044 MNLG
- Westerschelde: increased accident costs are 0.17 MLNG and financial savings are 0.514 MLNG
- Waddenzee: increased accident costs are 0.06 MLNG and financial savings are 0.427 MLNG

Throughout the regions, the tactic has a low stakeholder acceptance. Furthermore, one should note that the consequences of this tactic on recreational vessels were not assessed.

The tactic is unpromising in the approach to the Westerschelde. However, the tactic is promising in the Westerschelde and in the Waddenzee.

Tactic 3.2.1.A + 3.1.4 remove 50% of the buoys used as reference marks combined with increasing the visibility of buoys

**Tactic 3.2.1.B remove 100% of the buoys used as reference marks** (The tactic applies only to time period 2004 – 2010.)

**Specification:** These tactics aim at reducing the financial costs while their impacts on safety may be small. Buoys used as reference marks to determine position (so called "laterale boeien") are buoys that are either placed in a straight line to mark a dredged fairway or that follow the depth contours to mark safe navigable water. Tactic 3.1.4, increase the visibility of buoys, was defined to be implemented through different dedicated types of painting. This applies only to Tactic 3.2.1.A. These tactics do not apply to all buoys that are reference marks. Buoys within the harbors that have a special role in providing precise location information for ships would not be removed. Thus, the number of buoys within the harbors that would be removed is small. For cost analysis purposes we need to differentiate between buoys with lights (lichtboeien) and without lights (blinde tonnen). Tactic 3.2.1B applies only to the time period 2004 – 2010.
Analysis: These two tactics are dealt with together because a choice for one excludes the other. Tactic 3.2.1.B may only be implemented in the second time period 2004 - 2010.

The tactics have a strong regional character. Both tactics are unpromising for Open sea, Amsterdam/outside, Rotterdam/outside, and Approach Westerschelde because the financial savings are less than increased economic consequences from accidents. For the Open Sea, in the second time period the financial savings are slightly more than the economic consequences of accidents. However, because of the other possible negative impacts not taken into account here, such as the consequences of the tactic for recreational vessels, and the very low stakeholder acceptance, we classify this tactic as unpromising for this region.

Stakeholder acceptance for both of these tactics is very low.

Tactics 3.2.1.A (50% removal) and 3.2.1.B are both promising for the regions Small Harbor approaches, Waddenzee, and Westerschelde (Tactic 3.2.1.B applies only to the second time period). However, the tactics are mutually exclusive. Tactic 3.2.1.B (100% removal) introduces higher financial savings than Tactic 3.2.1.A (50% removal) and the other impacts are nearly the same. One should keep in mind that the stakeholder acceptance for both of these tactics is very low. One should also remember that 100% of buoys used as reference marks can be removed only if all professional vessels use ECDIS (Electronic Charts Display Information System).

Tactic 3.2.6 Shut down nine lighthouses

Specification: Under this tactic, the following nine lighthouses would be shut down to save money (the POLSS regions they primarily affect are in parentheses):

- Haamstede (Coastal waters)
- Egmond (Coastal waters)
- Noordwijk (Coastal waters)
- Ouddorp Haamstede (Coastal waters)
- Terschelling (Small harbor approaches)
- Scheveningen (Small harbor approaches)
- Texel (Coastal waters and Waddenzee)
- Vlieland (Coastal waters and Waddenzee)
- Ameland (Coastal waters and Waddenzee)

These lighthouses were selected because it was felt that they do not play a crucial role in navigation. Some of the lighthouses have effects on more than one POLSS region. The definition of this tactic assumes that the lighthouse buildings would remain and would be kept in good condition. Most of the lighthouses have historical value and the buildings are also used for other purposes.

Analysis: The lighthouses that would be shut down affect three of the POLSS regions, Coastal waters, Small harbor approaches, and the Waddenzee.

This is a promising tactic. The net financial savings in each region are larger than the costs (0.450 MNLG). The increase in accidents is very small (especially in the second period).

However, one should keep in mind that the stakeholder acceptance of this tactic is very low.
2.7.3 Piloting Tactics

The deep-sea piloting tactics reduce accidents, but are very expensive. The remote and "tailor-made" pilotage tactics save money, but increase accidents and the impacts from accidents. There are differences among the piloting tactics in stakeholder acceptance. All piloting tactics are promising. A decision about implementing any of these tactics requires a careful consideration of the tradeoffs between the benefits and financial costs. One should also remember that some of these tactics can not be implemented together – i.e., they are mutually exclusive.

Tactic 5.1.1 + 6.1.1 Implement “Tailor-made Pilotage”

Specification: Depending on the length of the ship, different piloting procedures would be followed in the outside and inside parts of the harbors (either normal piloting procedure with a pilot on board, remote piloting, nautical assistance or VTS support). Also, the tactic is defined slightly differently depending on the POLSSS region. The tactic would be applied to all ships that are over 60 meters long (ships below 60 meters are not piloted) and have transponders. For the first time period it is assumed that 25% of the vessels have transponders, and for the latter time period it is assumed that all the vessels have transponders. The tactic does not apply to ships carrying hazardous goods (IMO classification). Such ships would always be piloted with a pilot on board.

Analysis: There is a slight increase in the accident impacts (accident costs 0.25 MNLG) and in the impacts from disasters. However, the number of man-hours and sea miles traveled by pilot tenders related to piloted trips are significantly reduced. It is clear that the net financial savings would be very large (more than 10 MNLG).

Stakeholder acceptance of this tactic is on average low. However, there are differences among stakeholder groups. Active waterway users and maritime professionals on shore liked the tactic, but pilots disliked it (see Fig. 2.4. Tactic 5.1.1 + 6.1.1 was called in the survey as “Differential Navigational Support”).

This tactic is promising, but it requires that certain conditions be satisfied before it is implemented. Thus, vessels using “tailor-made piloting” must be equipped with a transponder, and transponder technology has to be installed in the VTS center.

Tactic 5.1.2 All ships are piloted by remote piloting LOA (excluding vessels carrying hazardous goods) (The tactic applies only to time period 2004 – 2010.)

Specification: Under the tactic, remote piloting (LOA) means that there is no pilot on board during any phase of the piloted trip. There is one pilot involved and he guides the vessel with the help of VTS. Remote piloting is applied to all ships over 60 meters long (ships below 60 meters are not piloted) that have transponders. For the time period 2004 – 2010 it is assumed that all the vessels have transponders. The tactic does not apply to ships carrying hazardous goods (IMO classification). They are always piloted with a pilot on board.

Analysis: This tactic leads to better results than the “Tailor-made Pilotage” tactic. It leads to a smaller increase of accidents and other impacts, while there are even more financial savings.
Stakeholder acceptance of this tactic is on average low. However, there are differences among stakeholder groups. Active waterway users and maritime professionals on shore liked the tactic, but pilots disliked it (see Fig. 2.5).

![Graphs showing stakeholder responses to tactics 5.1.1+6.1.1 and 5.1.2.](Image)

**Figure 2.5** – Means of Responses among Stakeholder Groups Related to Tactics 5.1.1+6.1.1 and 5.1.2. (1=total disagreement, 5 = total agreement)

**Tactic 5.2.1 Make deep-sea pilotage required for “sub-standard” ships**

**Specification:** Deep-sea piloting applies to the region from the Dover Strait to Rotterdam and Antwerp and to routes that vessels use when they pass by the Dutch coast. In these regions piloting is not obligatory at this moment, but may be done upon request. Deep-sea piloting affects the vessels that arrive at Rotterdam, Amsterdam, and the Westerschelde and that pass by the Dutch waters. This tactic makes deep-sea pilotage obligatory for “sub-standard” vessels that are over 60 meters long. The quality of ships or crews is considered to be “sub-standard” in ships that do not get permission from port authorities to continue their trip before some improvements. It is assumed that, for both analysis periods, 15% of the ships that arrive in Dutch harbors and that pass through Dutch waters in the North Sea are sub-standard.

**Analysis:** The direct savings in accident costs are only 0.85 MNLG, while the operating costs expressed in man-hours and sea miles of pilot tenders are very high. However, the tactic is promising, because it decreases the number of accidents. Stakeholder acceptance of the tactic is very high.

**Tactic 5.2.2 Make deep-sea pilotage required for vessels carrying hazardous goods.**

**Specification:** This tactic makes deep-sea pilotage obligatory for vessels carrying hazardous goods (IMO classification) if they are over 60 meters long.

**Analysis:** This tactic leads to a reduction in accidents, especially for ships carrying dangerous goods. Thus, the objective of the tactic is achieved. The direct savings in accident costs are only 1.22 MNLG while the operating costs expressed in man-hours and sea miles of pilot tenders are very high. However, the tactic is promising because it decreases the number of accidents. Stakeholder acceptance of the tactic is high.
Tactic 5.3.1 Use English as official communication language

**Specification:** This tactic means that all official communication, delivery of VTS information, and piloting, would be carried out in English. The use of English would lead to better understanding of what is happening by other users and thus safety might increase.

**Analysis:** As a result of better understanding of what is happening by other users, the number of accidents will be reduced. Only fishing or inland vessels with captains who have a poor knowledge of English will have degraded performance. In the second period we have assumed a more widespread understanding of the English language; thus, results are better. The tactic is promising because it produces benefits and has a very low implementation cost and very high stakeholder acceptance.

2.7.4 Vessel Traffic Services (VTS) Tactics

These tactics affect the collection of information relating to shipping traffic in a port area and the distribution of this information interactively to ships, pilots, and/or other officials. All of the tactics in this category were found to be promising and have high stakeholder acceptance. Overall, this group of tactics was the most cost-effective and appears to offer some good ideas for improving the maritime traffic system.

**Tactic 6.1.3: Ship domain approach is used when vessels enter or leave harbors**

**Specification:** “Ship domain approach” means that a ship is given a domain. Vessels are required to stay out of each others’ domain. Within its given domain, a ship can move freely. This procedure is not currently applied to maritime traffic, but is similar to the procedure used within the civil aviation air traffic control system. The tactic aims at decreasing the number of accidents. It is assumed that all on-shore procedures enabling the use of the ship domain approach already exist for both time periods.

**Analysis:** Use of the ship domain approach results in less traffic conflict and fewer accidents. The direct savings in accident costs are 1.44 MNLG, while the implementation costs are negligible. The only negative aspect of this tactic is that it can lead to delays. The busiest ports will experience the biggest delays. If each vessel visiting the Port of Rotterdam experiences a 5-minute delay when entering or leaving, than the total delay costs for Rotterdam would amount to 6.8 MNLG. The tactic has a high stakeholder acceptance. However, shippers may dislike the tactic because it may cause delays in entering the harbor.

The tactic is promising, but requires further research to be sure that the total costs of delay would be less than the benefits.

**Tactic 6.2.3: Require transponders on board for ship-to-shore data communication**

**Specification:** Transponders provide information on the course, position, and identification of vessels. They also provide information on the earlier voyages, next destination point, and on the speed of the vessels. This tactic assumes that transponders would be used to monitor vessels from shore and warn them of dangerous situations. It is assumed that the on-shore equipment necessary for receiving and using the information from transponders already exists.
Analysis: Better communication and data exchange from this tactic leads to fewer accidents, with a direct saving in accident costs of 4.51 MNLG. The implementation costs of the tactic are much less. Stakeholder acceptance of the tactic is very high. The tactic is promising.

Tactic 6.3.2: Elaborate the concept of Vessel Traffic Management Information Services (VTMIS)

Specification: This tactic aims at increasing the integration of all of the information that is important for safety and smooth traffic in ports. The goals are to:

- get a quicker, faster and more accurate supply of information to vessels.
- improve the planning of arrivals (i.e., information on cargo and the arrival time of a vessel are known more accurately).
- get more accurate information for contingency planning and search and rescue services.

Depending on the extent of the system, the implementation of the VTMIS system requires software that administers the information flows and their presentation and availability to different users. Onshore it requires the appropriate hardware to store, process, present, and link different information flows. It is expected that the initial implementation of the tactic would focus on basic operational information regarding the ship as a whole. Later, more detailed information regarding the ship’s cargo can be included.

Analysis: This tactic aims at increasing the integration of all the information that is important for safety (meteorological, tidal, and tactical traffic information) and for smooth traffic flow in and around ports. In this respect, it can also contribute to the implementation of the ship domain approach. In addition to its traffic regulation and information distribution functions, which enhance safety and capacity, the VTMIS would lead to indirect economic benefits from harbor services, more efficient piloting, on-time towing, customs, general registration, and increased space in the harbor. These indirect benefits were not assessed.

The direct savings for all the regions in accident costs are 1.84 MNLG. The costs are of the same order of magnitude (0.49 MNLG per region, or 1.86 MNLG in total). Stakeholder acceptance of the tactic is very high. The tactic is promising.

2.7.5 Search and Rescue Tactics

All of the SAR tactics increase the search and rescue capacity to save human lives, and all of them have some positive impacts. Furthermore, stakeholder acceptance is very high for all SAR tactics. Thus, all of the SAR tactics are promising. However, some of them are very expensive. We do not to make an explicit tradeoff between the financial cost of a tactic and the number of human lives it might save. This was found to be unacceptable among stakeholders in the survey (see Section 3.2). However, we highlight some results to suggest which of the promising SAR tactics would be most effective.

Tactic 7.1.1A: Add helicopter to double existing capacity

Specification: This tactic would double the helicopter capacity at the Royal Netherlands Navy helicopter station by buying a new helicopter with the same lifesaving capacity as the existing
helicopter (six persons per flight). In other words, instead of one helicopter standing by, two helicopters and their crews would be on permanent stand-by.

**Tactic 7.1.1B: Replace helicopter by one with double the existing capacity**

**Specification:** This tactic would double the helicopter rescue capacity at the Royal Netherlands Navy helicopter station by replacing the existing helicopter with one that has twice the capacity. In other words, instead of one helicopter having a live saving capacity of six people per flight, the helicopter stationed there would be able to carry 12 persons in addition to the crew.

**Tactic 7.1.1C: Replace helicopter by two with triple the existing capacity**

**Specification:** This tactic would increase the existing helicopter capacity six-fold by replacing the current six-passenger helicopter with two 18-passenger helicopters. The first helicopter would be stationed at the same location as the current helicopter; the second would be stationed on the Maasvlakte.

**Analysis of tactics 7.1.1.a, 7.1.1.b, and 7.1.1.c:** Tactics 7.1.1.a, 7.1.1.b, and 7.1.1.c all increase the existing helicopter capacity. The increase of helicopter capacity is promising only if the new helicopter capacity can be divided between different locations instead of locating all of the capacity in one place. Of these three tactics, Tactic 7.1.1.a is most promising, assuming that the second helicopter is located on an offshore platform. The location of a helicopter on a platform means that the crew is on the platform and is always available to respond. This means that the notice time is always small (we assumed a notice time of 25 minutes outside of working hours). Tactic 7.1.1.a is less effective if both of the helicopters are located at De Kooy. Tactic 7.1.1.a is even more promising than Tactic 7.1.1.c (which places two large helicopters along the coast) when it is assumed that one of the helicopters in Tactic 7.1.1.a operates from a platform (more people are saved and investment costs are less). However, the results might be different if the locations of large helicopters would be varied.

**Tactic 7.2.1: Maintain information on positions of all suitable helicopters**

**Specification:** This tactic would continuously update the positions and operational states of all helicopters in the Netherlands that are capable of performing SAR activities. The tactic requires setting up a helicopter air traffic information system, with the information being made available at the coordinating bodies (initially, the Coast Guard; later on, a Ministry-based group). The pilots of the (limited) number of helicopters suitable for this type of operation need to have training on SAR types of operations. We believe that most helicopter pilots who fly above water already receive such training.

**Analysis:** The impacts are very small.

**Tactic 7.2.2: Locate helicopter on platform in North Sea**

**Specification:** The permanent stationing of the current helicopter on an existing platform about halfway between the Hook of Holland and Harwich would decrease the response time of a helicopter to major accidents involving passenger vessels that occur on this route or on nearby routes. The tactic would require the crew to be located on the platform around the clock. The platform should be made suitable for the reception of possible survivors.
**Analysis:** Tactic 7.2.2 locates the present SAR helicopter on an offshore platform without increasing the capacity. Only operating costs related to crew are increased. Shifting the single helicopter to the new location improves the situation. Furthermore, if the crew is lodged on the platform, the notice time outside working hours can be reduced to 25 minutes (we assumed this to be the case for this tactic). We also analyzed this tactic without changing the present notice time. Even in this case, the tactic is an improvement over the current situation.

**Tactic 7.2.5: Make transponder information available at Coast Guard station.**

**Specification:** Transponders supply detailed information on vessels. As soon as a vessel is identified through an appropriate distress signal, information from the transponder on the type and dimensions of the vessel, the number of people on board, the type of cargo, and the current position would help to organize the search and rescue process.

**Analysis:** The impacts of the tactic are very small.

**Tactic 7.2.6: Improve capability of platforms and emergency vessels to handle victims.**

**Specification:** Currently, Coast Guard vessels do not have a lot of blankets, stretchers, and basic first aid needs aboard for the reception of large numbers of injured people or people suffering from hypothermia. This tactic would place these types of supplies on seven larger Coast Guard vessels and on four offshore oil and gas platforms.

**Analysis:** The impacts of the tactic are very small.

**Tactic 7.2.7: Add three Coast Guard vessels with helicopter platforms.**

**Specification:** This tactic would increase rescue capacity by buying three new Coast Guard units with helicopter pads. This means that a helicopter would be able to land and disembark people on each of the units. The existing helicopter would be stationed and maintained onshore. In order to have small sized vessels with a stable platform, SWATH (Small Waterplane Area Twin Hull)-type vessels would be used.

**Analysis:** See analysis results in connection with Tactic 7.2.9.

**Tactic 7.2.8: Decrease helicopter's notice time by keeping crew close to helicopter.**

**Specification:** Notice time (from the alarm until the helicopter takes off) would be decreased to 25 minutes by keeping the crew close to the helicopter. Already the crew is on call 24 hours a day, but the members of the crew are not necessarily close to the helicopter at all times.

**Analysis:** Nearly the same result as from having a helicopter located on a platform in the North Sea (Tactic 7.2.2) can be achieved if the notice time on De Kooy is reduced to 25 minutes outside of working hours (Tactic 7.2.8). This tactic is very cost-effective because it does not cost very much compared to other tactics (increased salary costs of keeping crew close to helicopter) and leads to an improved situation. One should note that this tactic (Tactic 7.2.8) is not the most effective in cases where there are large numbers of persons in the water.

**Tactic 7.2.9: Add large rescue vessel with helicopter platform and SAR tender vessels**

**Specification:** This tactic would invest in a high-speed, large rescue ship that has a platform that is stable at low speeds, and is accompanied by several small satellite tender vessels. The
ship would be capable of carrying about 250 people, and could travel at a sustainable speed of over 40 knots. The satellite vessels would collect people who have fallen into the water, and would bring them to the larger vessel. The high speed is required for quick response even during unfavorable conditions. Platform stability at low speed is required to enhance the interaction between the mother ship and the satellite vessels.

**Analysis:** Tactics 7.2.7 and 7.2.9, which were especially designed for large incidents with many persons in water, do not perform as well as the present SAR system, which depends on KNRM lifeboats for these incidents. The present density of the fast KNRM lifeboats along the coast means that more persons could be rescued in less time than could be achieved with only three (Tactic 7.2.7) or one (Tactic 7.2.9) large rescue unit. Both these tactics, 7.2.7 and 7.2.9 introduce big financial costs. The annualized financial costs are 15.6 MNLG and 8.8 MNLG for Tactics 7.2.7 and 7.2.9, respectively.

### 2.7.6 Contingency Planning Tactics

The analysis was based on estimating the impacts of the current salvage vessel WAKER. The tactics suggest that this vessel is either removed or another similar vessel is bought. We estimated the impacts of the WAKER for the entire POLSSS area. This was done because (1) there is only one WAKER and it provides help in many of the regions, and (2) the incident (a drifting) can occur in a different region from where the impacts (threatening a platform) are assessed. Only the impacts listed in Table 2.3 were considered. However, it should be kept in mind that the WAKER has functions unrelated to contingency planning, such as traffic research, fishery inspection, the cleaning of oil spills, which were not considered in assessing these tactics.

The removal of the WAKER was found to be unpromising whereas the doubling of the WAKER capacity was found to be promising. However, although the doubling of the capacity has some positive environmental impacts and is thus promising, it is very expensive and the savings in accident costs are much less than the increase in financial costs.

**Tactic 8.3.1: Get rid of the salvage vessel (WAKER)**

**Specification:** WAKER is the name of a salvage vessel operating in the North Sea. It is located in Den Helder. The main function of the WAKER is to prevent accidents by moving drifting vessels away from areas where they are likely to cause accidents. The WAKER is operated under a contract in which a fixed amount of 3.60 MNLG is paid each year. The removal of the WAKER would be implemented by terminating this contract.

**Analysis:** The impacts of the WAKER are the following:

- **Prevention of accidents:** We estimated that in the year 2000 the WAKER would prevent 0.469 strandings, 0.064 driftings against a platform, and 0.078 driftings against harbor entrances or piers. The total costs of these accidents would have been 0.2 MNLG (see Appendix F).

- **Reduction in platform shutdown costs:** Two shutdowns can be prevented per year, which introduce a saving of 0.4 MNLG.
• **Reduction in costs from platform collapses**: We estimated that the WAKER would prevent 52% of the 0.0318 fatal driftings per year. The replacement costs in case a platform is totally destroyed run from 10 MNLG to 600 MNLG (with an average of 50 MNLG). This means, the WAKER might prevent losses from platform collapses of between 0.165 MNLG and 9.92 MNLG per year.

Overall, this tactic seems unpromising when the higher estimate of the costs of the platform accident is used. The annual financial costs of the WAKER are 3.60 MNLG. Saving this amount of money must be balanced against the high potential costs cited above if the WAKER were not available.

**Tactic 8.3.2: Double the salvage vessel capacity**

**Specification**: In order to double the current salvage vessel capacity, a new vessel similar to the WAKER would be placed into service in the North Sea. The new vessel would be operated under a contract in which a fixed amount (3.60 MNLG) is paid each year.

**Analysis**: In case the objective of this tactic is to maximize the prevention of driftings against platforms, about 50% more benefits can be achieved than with a single WAKER. If the second vessel were located near the Westerschelde, there would be (nearly) no reduction in the number of driftings against platforms, while the number of strandings would decrease more than the amount that the single WAKER prevents, because more strandings occur near the Westerschelde than near Den Helder. However, the benefits of preventing a stranding seem to be much too low to justify a salvage vessel for this purpose.

This tactic is promising because it prevents some accidents and decreases some environmental risks. However, the benefits are low relative to the high costs.

**2.7.7 Sensitivity Analysis**

We performed sensitivity analysis on those context variables for which changes in assumptions might lead to big changes in casualty rates. In particular, we asked experts about the sensitivity of casualty rates to the following context variables: (1) transponders on ships, (2) ECDIS on ships, (3) quality of crew, and (4) special regulations for high-speed craft. At the expert meetings, the experts were asked how their estimates about the effects of the various tactics would change if these context variables were changed.

Overall, the conclusion is that sensitivity of casualty rates to the quality of crew is the highest. Next in importance are sensitivities to transponders and ECDIS on ships. This means that, if the use of transponders and ECDIS develops less quickly than we have assumed, the implementation of tactics requiring these instruments (e.g., Tactic 3.2.1B) will have to be postponed.

**2.8 Strategy Design Results**

A strategy is a sensible combination of promising tactics. We identified one strategy for each region. In this section we describe the process we used to design strategies, and the results of that process.
Figure 2.6 illustrates how the results from the analysis of individual tactics and stakeholder perceptions about acceptable risks (see Sec. 3) can be combined to produce strategies representing areas of acceptable combinations of costs and risks. Assume that the cost vs. risk situation that results from the current combination of policy instruments is represented by Point A. Assume that the cost-effectiveness analysis examined two new policy measures, one that would decrease safety but introduce cost savings (Point B represents a situation if this measure alone is implemented), and one that would increase safety but add costs (Point C represents a situation if this measure alone is implemented). The implementation of neither tactic alone would produce an acceptable outcome from the stakeholders’ perspective. However, introducing both of them might produce an acceptable situation (Point D).

![Diagram](image)

**Figure 2.6 – Identifying Acceptable Strategies.**

In developing strategies, we had to deal with a number of complexities. In particular, we had to take into account:

- **Interactions between tactics:** Some tactics are not disjunctive. Disjunctive tactics influence different subsets of accidents or situations that are not overlapping (e.g., they affect different areas within a POLSSS region). The impact of implementing a combination of such tactics is the sum of the separate impacts. If tactics are not disjunctive (i.e., they affect the same accidents in the same area), the impacts of implementing them together can not be estimated by summing up the separate impacts. However, in order to get a first rough estimate of the impacts of a strategy, we added up the impacts of its individual tactics. This approximation is reasonable when the relative impacts of each of the tactics are small.

- **Interactions between regions:** Impact assessment and strategy design proceed by regions. In some cases, however, a tactic cannot be implemented in only one region. For example, the tactics related to deep-sea piloting cannot be implemented in one region and not in the others, because deep-sea piloting needs to be made mandatory for all vessels
independent of the destination harbor. Thus, we present strategies by region, but one should keep in mind that in some cases the tactics need to be implemented either everywhere or nowhere.

The strategy design process for a given region includes the following steps:

1. Some of the tactics are mutually exclusive. These tactics are identified and it is made clear that only either one of them can be implemented.

2. Some of the promising tactics are grouped into strategy components. A strategy component is a set of tactics that fit together well or are dependent on each other so that they cannot be implemented without considering the interactions. Each strategy component is independent of the other tactics or strategy components.

3. The impacts of a strategy component are re-estimated if there are significant interactions among its constituent tactics (i.e., the impacts of the strategy cannot be approximated by the sum of the impacts of the tactics).

4. The tactics and strategy components included in a strategy for a given region are identified. The impacts of the strategy for the region for both time periods are presented in strategy scorecards in Appendix D in [Walker et al., 1998a]. One should note that decisionmakers can use the information in Table 2.7 or in the scorecards to identify other combinations of promising tactics for each region. Each tactic or strategy component within a regional strategy is independent of all other tactics and/or strategy components.

**Mutually Exclusive Tactics**

Some of the tactics are mutually exclusive; i.e., they cannot be implemented at the same time. We identified two such cases:

- Tactics 3.2.1A + 3.1.4 and 3.2.1 B cannot be implemented at the same time for the time period 2004-2010. Both of these tactics are promising, but Tactic 3.2.1B is more effective. Thus, we suggest that Tactic 3.2.1B be included in regional strategies.

- Tactics 5.1.1 + 6.1.1 and 5.1.2 related to remote piloting are mutually exclusive. Both of them are promising. In defining the regional strategies and estimating their impacts, we used Tactic 5.1.1+6.1.1.

**Suggested Strategy Components**

We suggest two strategy components.

- **Tactics 5.2.1 and 5.2.2 related to deep-sea piloting.** They are both promising, but they are not independent, since there are sub-standard ships that also carry hazardous goods (oil tankers). We decided that these two tactics form one strategy component. Because of the interactions between the tactics, the impacts of this strategy component were estimated separately. These tactics cannot be implemented in one region and not in the
others, because deep-sea piloting needs to be made mandatory for all vessels independent of the destination harbor (e.g., we are not able to request deep-sea piloting only for vessels that are going to Amsterdam). Thus, the strategy component comprising these tactics includes their effects over all the POLSSS regions. The impacts for this strategy component over all POLSSS regions are shown in Appendix D in [Walker et al., 1998a] in connection with the strategy scorecard for the Open Sea region.

- **Tactics 6.1.3, 6.2.3, and 6.3.2.** All three of these tactics focus on improving the VTS system. In calculating the impacts for Tactics 6.2.3 and 6.3.2 for the Open Sea region, it was assumed that the improved VTS technology is implemented in all harbors. However, the financial costs of Tactics 6.2.3 and 6.3.2 are related to the improvement of VTS systems in the harbors, not on the open sea. So, we estimated the financial costs for VTS improvement in each harbor and show these costs together with the strategy for the outside parts of these harbors. Thus, the financial costs for these tactics on the Open Sea scorecard are shown to be zero to avoid the double counting of financial costs. There may be further financial synergy between these tactics that we did not estimate in our analysis.

Table 2.7 presents an overview of the tactics and strategy components that were included in each regional strategy. After the detailed analysis of the screening results is carried out, the suggested strategies should be reviewed. SAR and CP tactics are not shown in Table 2.7 because they apply to all the regions; all SAR tactics are promising. The removal of the WAKER was found to be unpromising whereas the doubling of the WAKER capacity was found to be promising. The impacts of each regional strategy are shown in Appendix D in [Walker et al., 1998a] in connection with the regional scorecards.
### Table 2.7 - Regional Strategies

<table>
<thead>
<tr>
<th>Promising Tactics/ Strategy Components</th>
<th>Open sea</th>
<th>Coastal waters</th>
<th>Amsterdam / outside</th>
<th>Amsterdam / inside</th>
<th>Rotterdam / outside</th>
<th>Rotterdam / inside</th>
<th>Approach Westerschelde</th>
<th>Small harbor approaches</th>
<th>Westerschelde / East</th>
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<tbody>
<tr>
<td>1.1.1 (implement a new TSS to Westerschelde.)</td>
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<td>1.1.4 (implement a new TSS between Maaswest inner and Maaswest outer)</td>
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<td>1.2.5+1.6 (No fishing or recreational vessels are allowed in TSSs. Combined with mandatory cross-over areas, entrance to, and exits from lanes.)</td>
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<td>1.3.3 (Use different lanes for different types of ships.)</td>
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<td>1.3.4 (Widening of lanes by 20%)</td>
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<td>3.1.6 (50% of buoys with a light are replaced by buoys without a light)</td>
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<tr>
<td>3.2.1.A + 3.1.4 (Remove 50% of the buoys used as reference marks) or 3.2.1.B (Remove all the buoys used as reference marks, only for the time period 2004 - 2010)</td>
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<td>3.2.6 (Shut down nine lighthouses)</td>
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<tr>
<td>5.1.1 + 6.1.1 (Implement &quot;Tailor-made Pilotage&quot; or 5.1.2 All vessels are piloted by remote pilotage, only for the time period 2004 - 2010)</td>
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<td>5.2.1 and 5.2.2 (Make deep-sea pilotage required for 'sub-standard' ships and vessels carrying hazardous goods)</td>
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<tr>
<td>5.3.1. (Use English as official communication language.)</td>
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<td>6.1.3 (Ship domain approach is used when vessels enter or leave harbors), 6.2.3 (Require transponder on board for ship-to-shore data communication) and 6.3.2 (Elaborate the concept of VTMS)</td>
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* = Tactic or Strategy Component is included in the strategy for region
Assessment of Regional Strategies Based on Results from Survey I

Results from Survey II, which focused on the non-risk-related acceptability of the tactics, were used to fill in the stakeholders' acceptability for each tactic in the scorecards. These results were included in the analysis of the tactics presented in Sec. 2.7. Survey I focused on stakeholders' risk acceptance. Among the general conclusions from the survey was that the stakeholders do not find the current risk situation acceptable, and preferred to increase the acceptability of the current situation through decreasing risks instead of increasing benefits. Relating these general conclusions to the regional strategies shown in Table 2.7, we can make some inferences about the stakeholders' opinions of the strategies.

- **Regional strategies for all regions besides Westerschelde/East and Waddenzee.** Impact by impact (except for financial costs), each of these regional strategies improves the current situation or leaves it the same. Based on the survey results, the stakeholders did not find the current combination of risk and benefits acceptable. In the stakeholders' opinion, the situation should be improved by increasing safety. These results indicate, therefore, that the strategies for these regions would be highly acceptable to the stakeholders.

- **Regional strategies for the Westerschelde/East and Waddenzee.** These regional strategies would introduce cost savings, but they would result in some decreases in safety or in the environmental situation (during the first time period in Westerschelde/East and for both time periods in the Waddenzee). These decreases in safety would not be acceptable to the stakeholders. The survey results say that financial savings should not compensate decreased safety or increased environmental damage. During the second time period, the Westerschelde/East strategy leads to an improved situation, which would make it acceptable. In both these regions, a strategy component including only the VTS tactics (Tactics 6.1.3, 6.2.3, and 6.3.2) would lead to an improved situation with respect to all impacts besides financial costs.
3. Surveying Stakeholders About Acceptability of Risks and System Changes

3.1 The Research Problem

Often, people’s perceptions of risk are more important to the success of an enterprise than the real risks. For example, after a serious airplane accident, ridership often declines, while the safety of the system remains unchanged. In POLSSS, we were interested in the perceptions of stakeholders about the safety situation in the North Sea and surrounding areas, and about the effectiveness of various current and new policy instruments for maintaining safety in the North Sea and surrounding areas. Stakeholders here refer to all the groups of people who are close to professional maritime activities (sailors, fishermen, government officials) and also to people who may suffer from the consequences of maritime accidents. The surveys were focused on opinions within these specialized groups and we did not try to cover the interests of the entire Dutch population.

To address the research questions mentioned in Chapter 1, two surveys were carried out:

- **Survey I** focused on the acceptability of risks. The main goal of this survey was to find out how stakeholder groups accept different risks involved in maritime activities. The survey asked questions about two types of accidents: regular accidents (*reguliere ongevallen*) and disasters (*rampen*).

- **Survey II** examined the acceptability of different measures. The main goals of the survey were to assess the *draagvlak* -- the non-risk related acceptability, practicality, and effectiveness -- of the measures that are used currently, and to assess the *draagvlak* of several new measures (which we call tactics) that were defined in the cost-effectiveness analysis of the POLSSS project.

Both surveys covered regions that were part of the POLSSS project and focused primarily on professional sea shipping vessels. Detailed descriptions of the scope of the POLSSS project and of the regions that are considered within POLSSS can be found in Chapter 2.

The two parts of the project -- the stakeholder surveys and the cost-effectiveness analysis -- are closely linked. Risks were measured in the same way in the two parts of the project. The cost-effectiveness analysis traded off the costs of tactics and their benefits in terms of safety improvements and produced promising strategies. The results from Survey I were used to provide insight into stakeholder acceptability of the strategies (see Sec. 2.8). The results from Survey II were used in the evaluation of the tactics in cost-effectiveness analysis (see Sec. 2.7).

This chapter presents the details of the design of the two surveys, and their results.
3.2 Survey I

3.2.1 Executing Survey I

The acceptability of risk is contextual and not absolute. People accept risks because they get some benefit from the actions involving risks.⁵ If one is asked whether or not he or she would be willing to accept a risk of one in a million, the answer typically depends on the specific hazard being faced and the potential benefit from accepting this risk. Thus, an acceptable risk for an individual can be defined as a level of risk for which the benefits are large enough to justify taking the risk. The survey needed to be specific about both dimensions of risk acceptability: risks and benefits.

Defining Risk

Risk includes two factors: (1) an unwanted consequence, and (2) uncertainty about whether this consequence actually happens. In this survey we focused on four types of unwanted consequences (four dimensions of risk):

- number of accidents
- number of deaths or injuries caused by accidents
- environmental damage caused by accidents (we use the amount of oil spilled as a result of accidents as a proxy measure of environmental damage)
- economic damage

These measures were selected because they represent the dimensions of risk that are of interest throughout the POLSSS project. They are among the specific impacts that were used in the cost-effectiveness analysis.

For regular accidents, the four dimensions of risk were separated and questions were formulated for each of them separately. The uncertainty related to each consequence was defined by using the expected yearly consequences (expected yearly number of accidents, expected yearly number of deaths or injuries, etc.). In Part II of the survey, which focused on disasters, we described four different scenarios, which together included all dimensions of risk. The consequences related to the disasters were described with short paragraphs. The four disaster scenarios were:

1. A ferry accident with 106 deaths.
2. An oil-tanker accident with large environmental consequences.
3. A chemical-tanker accident. The toxic cloud makes it necessary to organize large evacuations. 20 people on shore die.
4. A platform collapses and 20 people working on the platform die.

The acceptance of more or less risk is always related to an existing (or base case) situation. For example, the estimate that an average of 4 deaths per year would result from a policy has different meaning depending on whether there are currently on average ten or two deaths per year. Throughout the survey, therefore, we focused on relative changes: changes in risk or

⁵ "Benefit" needs to be understood broadly. Benefits that we get from accepting risks are seldom only monetary benefits; they include personal benefits that are hard to measure.
benefits relative to the current situation. By combining information from different sources, we ended up using the following figures to describe the current situation.\(^6\)

- The expected yearly number of sea shipping accidents is 292.
- The expected number of deaths or injuries caused by sea shipping accidents is 10.
- The expected yearly amount of oil spilled as a result of sea shipping accidents is 1600 m\(^3\).
  (The yearly operational amount of legal and illegal oil spills is about 16000 m\(^3\).)
- The expected yearly economic damage resulting from accidents is about 100 MNLG.
- A ferry disaster with 10 or more deaths is expected to happen once in 55 years.
- An oil tanker disaster with an oil spill of more than 30000 m\(^3\) is expected to happen once in 65 years.
- A chemical/gas tanker disaster with 10 or more deaths on shore and evacuation is expected to happen once in 8000 years.
- An accident with a platform with 20 or more deaths is expected to happen once in 36 years.

**Defining Benefit**

The “benefit” of maritime activities is an ambiguous concept that is interpreted differently by different stakeholders. There is no perfect measure of the benefits persons get when they accept risks related to maritime activities. The alternatives we considered for the “benefit” measure were:

- National benefits measured by monetary indicators (e.g., the national net product, toegevoegde waarde)
- Monetary safety costs (the benefit would be a reduction in safety costs paid by the government)
- Benefits linked to personal costs (e.g., the price of imported goods)
- Subjective benefits (a subjective scale from −3 to 3 for benefits)

In Survey I, we decided to primarily use the subjective benefit measure. “Het maatschappelijk nut van maritieme activiteiten” was defined to include all the benefits that people personally perceive for all the good things that sea transport brings, including national benefit, industry benefits, employment, and less obvious things such as the low price level for imported goods. This subjective benefit was measured with a subjective scale that varied from “−3” to “3”, where “−3” meant a big decrease in subjective benefits and “3” meant a big increase in subjective benefits. We also decided to ask an additional set of questions in which benefits were linked to safety costs and personal costs.

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\(^6\) All types of accidents, excluding the accidents that happen to recreational vessels only, are included into the survey, although the POLSSS project focuses only on accidents that can be prevented by traffic management measures. Different types of accidents cannot be separated in a survey because the acceptance of environmental consequences, for example, should be the same regardless of whether the damage is caused by a collision or by a fire on board. It is also important to give respondents a good overview of the safety situation covering all the accidents.
Survey Questions

Survey I consisted of two parts. The first part contained questions related to regular accidents; the second part contained questions related to disasters. Throughout Survey I, the following types of questions were asked:

- Do you accept the current combination of risks and benefits?

- If the risk were increased (by 10%, 20% or 30%), how much would the benefit need to be increased to make the resulting situation acceptable (a change in subjective benefit of 0, 1, 2, or 3)?

- If the risk were decreased (by 10%, 20% or 30%), how much can the benefit be decreased for the situation to remain acceptable (a change in subjective benefit of 0, -1, -2, or -3)?

For the last two types of questions, The respondents had an option to say “never acceptable” in presented combinations of risks and benefits. This option was not added when it was asked whether the respondents accepted the current situation.

3.2.2 Results of Survey I

Respondents

DGG distributed Survey I. 720 copies were sent out; 173 completed surveys were returned (22% of the copies that were sent out). The two largest groups of respondents were professional sailors and civil servants. Furthermore, these two categories had high response rates as a proportion of the number of copies of the survey that were sent out. Some stakeholder groups were under-represented. For example, we received only 4 responses from shipowners and no responses from platform crewmembers, although 92 copies of the survey were sent to shipping companies and 40 copies to platform crewmembers.

In our analysis, we aggregated the 16 stakeholder categories into three larger groupings:

- Active waterway users: those who personally face the risks of maritime traffic in their everyday work (sailors, fishermen, pleasure craft skippers, inshore traffic skippers, sailor representatives, shipowners, platform crewmembers, oil company representatives, pilots) (referred to as users).

- Professionals on shore: those civil servants and government officials who work with maritime traffic related issues but who do not face the risks of maritime traffic personally (referred to as professionals on shore).

- The remainder of the stakeholders: those who are not directly involved in maritime traffic through their work (e.g. members of environmental organizations) (referred to as others).

The lack of responses from some stakeholder groups means that the results cannot be considered to be a good representation of the opinions over all the stakeholder groups. One possible explanation for the low numbers of respondents in some of the categories is that the surveys were not distributed further when they were sent to one person in a branch organization. The survey was also difficult. The fact that some stakeholder groups were
under-represented and that there were no responses from ferry passengers or citizens of coastal cities should be kept in mind when viewing the general conclusions.

We also received many more "never acceptable" answers than expected. That option offered respondents an easy way to avoid giving their opinions of the tradeoff between risk and benefits (although respondents who work at sea accept the risk associated with their profession). With respect to questions on the acceptance of the current situation, there was no "never acceptable" option. As a result, the responses we received on these questions were sufficient to draw valid conclusions. For other questions, the large number of "never acceptable" responses led to fewer other responses in which the benefits were changed. Thus, it was not reliable to make conclusions based on the changes in benefits alone. The conclusions presented here are based instead on the number of "never acceptable" responses compared to the number of responses in which the benefits were changed.

General Conclusions

Survey I showed that, in general, the respondents did not find the current risks in the POLSSS regions acceptable. For all risk dimensions -- number of accidents, environmental damage, economic damage, and human victims -- the majority of respondents did not accept the current situation (see Fig. 3.1). Also, for platform and oil tanker disasters, the majority of respondents did not accept the current situation (see Fig. 3.2). However, the majority of respondents accepted the current risks of a ferry disaster and a chemical/gas tanker disaster. Overall, the respondents think positively of attempts to decrease risks in POLSSS regions.

![Acceptance of current risks of regular accidents](image)

**Figure 3.1** – Number of Stakeholders Who Accepted ("ja") or Did Not Accept ("nee") the Current Situation for Risk Dimensions in Part I of Survey I.
The respondents preferred to increase the acceptability of the current combination of risks and benefits through decreasing risks instead of increasing benefits. Comparing different dimensions of risk shows that environmental damage was less acceptable than other types of risk. For example, comparing a ferry disaster including more than 10 deaths and an oil-tanker disaster with an oil spill of 30000 m$^3$, the oil tanker disaster was less accepted although the probability of that disaster to happen is smaller.

The respondents had an option to say “never acceptable” in every question for any presented combination of risks and benefits. For example, when the respondents was asked that “if the number of accidents increases 20%, how much would the benefit need to be increased to make the resulting situation acceptable?” they had an option to say that the described situation is “never acceptable”. There were fewer of these “never acceptable” responses for economic damage (average over questions is less than 30%) than for other risk dimensions (average over 50%). This means that it is more acceptable to compensate economic damage by increasing benefits than it is for other risk dimensions. With risk dimensions involving human victims there were more “never acceptable” responses. Many stakeholders would not find it acceptable to compare human lives and monetary impacts.

The implications of these results for the cost-effectiveness analysis of tactics are the following:

- Tactics that decrease risks instead of saving money are more acceptable.
- Tactics that decrease environmental impacts more than other impacts (e.g., economic consequences) are more acceptable.
- Compensating for an increase in the economic damage caused by accidents by increasing benefits is acceptable.
- Compensating for an increase in ecological damage by increasing benefits is not acceptable.
- Compensating for an increase in the number of human victims by increasing benefits is not acceptable.
In situations in which risks were changed, an average of 20% of the respondents were not ready to decrease their subjective benefit at all, even if the risks were decreased; i.e., they replied “never acceptable” even when the risk decreased. Thus, they felt that even the decreased risks cannot be made acceptable by compensating with any benefit. However, the rest of the respondents were ready to decrease their subjective benefits in order to decrease risks. Very few respondents were ready to accept any increase in risks without getting compensated by an increase in subjective benefit.

There were some differences in risk acceptance among different groups of stakeholders. Active waterway users accepted risks slightly less compared to maritime professionals who work on shore. This is related to a common phenomenon that the acceptance of risk depends on whether the person faces the risks personally or not.

Survey I also showed that respondents had different perceptions of risk depending on whether the risks were current risks or changed risks. For example, a common result was that the benefit increase required to make the current situation acceptable was larger than the benefit increase required in a situation in which the risk was increased. This suggests that the perceptions about traffic management measures used currently cannot be directly compared with the perceptions about new tactics. Thus, in assessing the acceptance of tactics, the survey responses about tactics should not be compared with responses about current traffic management measures; responses about tactics should be compared with each other.

Survey I used mainly the subjective benefit measure in evaluating the acceptance of risks. Additional questions were asked to evaluate the correspondence between subjective benefits and monetary measures for benefits (either personal costs such as the price of a ferry ticket or governmental safety costs). Generally, it is not possible to make a reliable link between money and the subjective benefit measure over the respondents. There was a large variation among respondents, so the correspondence between subjective benefit measure and money varied greatly from person to person. However, a general observation from the survey was that, in order to reduce the risks, the respondents found it acceptable to increase their personal costs slightly. They did not think that these increases in costs would significantly change their subjective benefit.

3.3 Survey II

3.3.1 Executing Survey II

The objectives of Survey II were to collect information from stakeholders about their perceptions of the effectiveness of existing policy and about their future needs. To address the objectives related to the current policy, we asked questions about the traffic management measures that are currently being used in the Dutch sea shipping areas. To address the objectives on future needs, we asked stakeholders their opinions about tactics that were defined for the cost-effectiveness analysis of the POLSSS project.
Survey II consisted of three parts to identify the respondents’ perceptions related to tactics and current traffic management measures:

- **Part I: Evaluation of current traffic management measures.** The current measures were evaluated with respect to their ability to increase safety, their practicality, and their cost-effectiveness.

- **Part II: Evaluation of tactics.** Respondents were asked whether a tactic is a good idea, how it contributes safety, and whether it would be practical to use.

- **Part III: Comparison of current measures.** A selection of current traffic management measures were compared to each other with respect to their ability to increase safety, their reliability, and their relative cost-effectiveness.

Selection of current measures

Survey II included 17 current traffic management measures, which were selected from an inventory list of 30 current measures [DGG, 1997]. Table 3.1 lists the 17 measures and provides short descriptions of each of them.
### Table 3.1 – Current Measures Included in Survey II

<table>
<thead>
<tr>
<th>Measure</th>
<th>Category</th>
<th>Measure described in Dutch</th>
<th>Measure described in English</th>
</tr>
</thead>
</table>
| 1       | Routing  | • Routeringstelsels boven de Waddeneilanden.  
          |          | • Routeringstelsel Friesland.  
          |          | • Routeringstelsels aanloop Rotterdam.  
          |          | • Routing system above the Frisian Islands.  
          |          | • Routing system Friesland.  
          |          | • Routing system approach Rotterdam.  
| 4       | Routing (Location of platforms and other offshore installations) | • Verbod produktieplatforms in of in de nabijheid van verkeersscheidingstelsels.  
          |          | • It is forbidden to establish production platforms in or near traffic separation schemes.  
| 5       |          | • Het plaatsen van objecten in gebieden van druk verkeer zonder verkeersscheidingstelsels (vss) is in de VSS verbindende routes niet toegestaan (het “clearway principe”), maar daarbuiten wel, echter alleen met uitgebreide veiligheidsmaatregelen.  
          |          | • Establishing objects in heavy traffic areas without traffic separation schemes (TSS) is not allowed in TSS connecting routes (the “clearway principle”), but it is allowed, together with strict safety measures, to establish objects outside these routes.  
| 6       |          | • Het boren in de vaarbanen van een verkeersscheidingstelsel wordt zoveel mogelijk beperkt. Boren is alleen mogelijk met uitgebreide veiligheidsmaatregelen en indien de geboorde put definitief zal worden verlaten (dat wil zeggen dat er geen produktieplatform geïnstalleerd mag worden op dezelfde positie).  
          |          | • Drilling in lanes of traffic separation schemes is limited as much as possible. Drilling is only allowed with extensive safety measures and only when the well is left after the drilling (which means that a production platform is not allowed on the same position).  
| 7       |          | • Het instellen van een veiligheidszone van 500 m rond offshore installaties.  
          |          | • A 500 m safety zone around offshore installations.  
| 8       | Waterway marking | • Vaarwegmarkering.  
          |          | • Fairway marking.  
| 9       | Information | • Actualiseren van schriftelijke informatiedragers aan boord.  
          |          | • Updating written information on board.  
| 10      | Piloting  | • Loodspligt bij havenaanlopen voor schepen langer dan 60/70 m.  
          |          | • Compulsory pilotage at port approaches for ships with a length of 60/70 m or more.  
| 11      |          | • Systeem van verklaringhouders.  
          |          | • System of exemption certificates.  
| 12      | VTS      | • Verkeersbegeleiding (VBS).  
          |          | • Vessel Traffic Services (VTS).  
| 13      | SAR and Contingency planning | • Search and Rescue (SAR).  
          |          | • Search and Rescue (SAR).  
| 14      |          | • Bergingsvaartuig (WAKER).  
          |          | • Salvage vessel (WAKER).  
| 15      |          | • Global Maritime Distress and Safety System (GMSS).  
          |          | • Global Maritime Distress and Safety System (GMSS).  
| 16      |          | • NEREUS: Meldingsplicht in Nederlandse havens voor schepen met gevaarlijke lading, in combinatie met een scheeps- en ladinginformatienetwerk tussen Kustwachtcentrum en havens.  
          |          | • NEREUS: Compulsory reporting in Dutch seaports for vessels with hazardous goods in combination with a network between the Coast Guard Center and Dutch seaports for the exchange of information on hazardous and polluting goods on board.  
| 17      | Laws and regulations | • Gedragsregelgeving  
          |          | • Rules of conduct.  

### Selection of tactics

Survey II included a subset of the tactics that were analyzed in detail in the cost-effectiveness analysis. The tactics that were included were selected based on a preliminary analysis about
their effectiveness. Table 3.2 lists the 14 tactics that were included in Survey II and provides a short description of each of them.

Table 3.2 – Tactics Included in Survey II.

<table>
<thead>
<tr>
<th>Category</th>
<th>Tactic</th>
<th>Tactic described in Dutch</th>
<th>Tactic described in English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing</td>
<td>1.1.1</td>
<td>Nieuw routingsstelsel voor de Westerschelde.</td>
<td>Implement a new routing system for the Westerschelde.</td>
</tr>
<tr>
<td></td>
<td>1.2.1</td>
<td>Een vaarverbod voor schepen met gevaarlijke lading in bulk in het Oostgat.</td>
<td>Vessels carrying hazardous goods in bulk are not allowed to use the Oostgat channel.</td>
</tr>
<tr>
<td></td>
<td>1.2.5+</td>
<td>Een verbod voor visserschepen om te vissen in VSS en voor recreatiesvaart om zich te begeven in VSS, in combinatie met verplichte oversteekplaatsen en in- en uitgangen naar de VSS.</td>
<td>No fishing is allowed in TSS and no recreational vessels are allowed in TSS, combined with mandatory cross-over areas, entrances to, and exits from lanes.</td>
</tr>
<tr>
<td></td>
<td>1.1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterway marking and</td>
<td></td>
<td>Vervanging van sectorkaders in de Westerschelde door RACONs.</td>
<td>Replace &quot;sector light&quot; markings with RACONs in the Westerschelde.</td>
</tr>
<tr>
<td>Maritime signaling</td>
<td>3.2.1A</td>
<td>50% van de boei die het veilig vaarwater aangeven, worden verwijderd (laterale betonning).</td>
<td>Remove 50% of the buoys that mark the safe fairways (lateral buoy)</td>
</tr>
<tr>
<td></td>
<td>3.2.1B</td>
<td>Alle boei die het veilig vaarwater aangeven, worden verwijderd (laterale betonning).</td>
<td>Remove all the buoys that mark the safe fairways (lateral buoy)</td>
</tr>
<tr>
<td></td>
<td>3.2.6</td>
<td>Negen vuurtorens worden gedoofd.</td>
<td>Shut down nine lighthouses</td>
</tr>
<tr>
<td>Piloting</td>
<td>5.1.2</td>
<td>Voor alle schepen die aan bepaalde voorwaarden voldoen: loodsen op afstand (LOA).</td>
<td>All vessels (under certain conditions) are piloted by remote pilotage</td>
</tr>
<tr>
<td></td>
<td>5.1.1+</td>
<td>Gedifferentieerde navigatieondersteuning.</td>
<td>Implement &quot;Differential navigational support&quot;</td>
</tr>
<tr>
<td></td>
<td>6.1.1</td>
<td>Engels als officiële communicatie taal met betrekking tot verkeersbegeleiding en beoordeling in de aanlopgebieden.</td>
<td>Use English as the official communication language for Vessel Traffic Services (VTS) and pilotage in approaches</td>
</tr>
<tr>
<td></td>
<td>5.3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VTS</td>
<td>6.2.3</td>
<td>Transponder aan boord voor datacommunicatie tussen schip en wal.</td>
<td>Require transponder on board for ship-shore data communication</td>
</tr>
<tr>
<td></td>
<td>6.3.2</td>
<td>Uitwerking van het concept van Vessel Traffic Management Information System (VTMIS)</td>
<td>Elaborate the concept of Vessel Traffic Management Information System (VTMIS)</td>
</tr>
<tr>
<td>SAR and contingency</td>
<td>7.2.2</td>
<td>Het plaatsen van helicopeters op een centrale plaats in de Noordzee.</td>
<td>Locate helicopters in a central place in the North Sea</td>
</tr>
<tr>
<td>Planning</td>
<td>8.3.1</td>
<td>Het verdubbelen van de bergingsschepen</td>
<td>Double the salvage vessel capacity</td>
</tr>
</tbody>
</table>

Designing the questions

Five statements about each current traffic management measure were presented to the respondents:

1. I know this measure.
2. This measure increases safety.
3. This measure is practical to use. (For some measures: This measure is reliable.)
4. It is possible to track offenders and sanction them.
5. The measure is cost-effective (worth the costs).

The first statement was relevant for all current measures. If respondents did not know a measure, there was no need for them to fill in the other questions related to that measure. The other statements did not apply to all measures, so some of the questions were left out for some
of the measures. For each presented statement, the respondent either agreed or disagreed using a scale from 1 to 5 (1 = total disagreement, 5 total = agreement).

For the current measures, we also asked respondents to compare five pairs of measures with respect to their effectiveness and practicality. The respondents were asked, for example, whether DGPS or RACON is more effective in increasing safety. The respondents could choose one of five response options: either one of the measures is preferred, both, none, or don’t know.

With tactics, the respondents were given the following statements, with which they either agreed or disagreed.

1. I think that this new measure is a good idea.
2. This measure does not change the current safety level.
3. This new measure will increase safety.
4. This new measure will be practical to use.

3.3.2 Results of Survey II

Respondents

DGG distributed Survey II. 599 copies were sent out; 155 completed surveys were returned (26% of the copies that were sent out). The two largest groups of respondents were professional sailors and civil servants, followed by pilots and pleasure craft skippers. Compared to Survey I, we got relatively fewer responses from civil servants and more from pleasure craft skippers. Survey II required more special knowledge of traffic management measures. Thus, the number of civil servants may have been lower because they do not experience the traffic management measures themselves, since they do not work on waterways.

We received no responses from platform crewmembers for either of the surveys. One possibility is that the surveys that were sent to one person in an oil platform branch organization were not distributed any further. This may have also happened with some other branch organizations. These groups could perhaps have been reached by sending reminders.

In our analysis, we aggregated the 11 stakeholder groups into four larger groupings:

- Active waterway users: those who personally face the risks of maritime traffic in their everyday work (sailors, fishermen, pleasure craft skippers, inshore traffic skippers, sailor representatives, shipowners, platform crewmembers, oil company representatives, pilots) (referred to as users).

- Pilots

- Professionals on shore: those civil servants and government officials who work with maritime traffic related issues but who do not face the risks of maritime traffic personally (referred to as professionals on shore).
• The remainder of the stakeholders (those who are not directly involved in maritime traffic through their work).

In Survey II, we identified pilots as a separate analysis group because, for some of current measures and proposed tactics, their opinions differed significantly from the opinions of other stakeholders who work on waterways (e.g., professional sailors).

**General Conclusions**

Both in evaluating current measures and in evaluating tactics, the responses to the different statements concerning the same measure were strongly correlated with each other. This means that the respondents had a general opinion of the measure or the tactic and their responses to all the presented statements reflected this opinion. For example, if the respondents thought that a tactic is a good idea, then they also thought it would increase safety and would be practical to use. This result implies that we can describe the acceptance of measures or tactics in the cost-effectiveness analysis by using a single indicator.

Survey II showed that the respondents generally agreed that all the current traffic management measures are practical, increase safety, are reliable, and are worth the costs (see Table 3.3). However, there were some differences among stakeholder groups. For example, for the system of exemption certificates, active waterway users, professionals on shore, and others agreed with the presented statements, whereas pilots generally disagreed with them (see Fig. 3.3).

![Compulsory pilotage at harbor approaches](image1)

**Figure 3.3** – The Means of Responses Within Stakeholder Groups Related to Piloting Measures (1 = total disagreement, 5 = total agreement).

In comparing pairs of current traffic management measures, a large proportion of respondents did not have any preferences between measures. However, from the given responses we can draw the following conclusions:

• Waterway marking is preferred over (D)GPS.
• (D)GPS is preferred over the use of RACONs.
• VTS and remote pilotage are equally preferred.
• Compulsory pilot on board is preferred over remote piloting.
- Stricter demands for education is preferred over increased Maritime Traffic Control.

Survey II showed that the tactics most preferred by respondents were to use English as official language, to use transponders on board for ship-to-shore data communication, to increase use of VTMIS, and to define a new TSS for the Westerschelde (see Table 3.4). The most disliked tactics were to remove buoys that are used as reference marks, and to shut down nine of the lighthouses. Almost all respondents thought that these were not good ideas and that they would decrease safety. There were some large differences in opinion among stakeholder groups. In particular, pilots disliked the piloting tactics whereas other groups thought that most of these tactics would be good ideas (see Figure 2.4). Pilots also disliked changes in routing whereas other groups of stakeholders liked them more (see Figure 3.4).

Table 3.3 – Means of Responses to Statements Related to Current Traffic Management Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Measure number</th>
<th>Increase to security</th>
<th>Practical to use</th>
<th>Reliable</th>
<th>Possible to sanction offenders</th>
<th>Cost-effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing above Frisian Islands</td>
<td>1</td>
<td>4.7</td>
<td>4.4</td>
<td>3.6</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Routing Friesland</td>
<td>2</td>
<td>4.7</td>
<td>4.4</td>
<td>3.5</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Routing Rotterdam</td>
<td>3</td>
<td>4.7</td>
<td>4.4</td>
<td>3.8</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>No platforms in TSS</td>
<td>4</td>
<td>4.4</td>
<td>4.2</td>
<td>2.8</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>No objects in heavy traffic areas</td>
<td>5</td>
<td>4.4</td>
<td>3.9</td>
<td>-</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Limited drilling in TSS</td>
<td>6</td>
<td>3.8</td>
<td>3.8</td>
<td>-</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Safety zone around platforms</td>
<td>7</td>
<td>4.7</td>
<td>4.3</td>
<td>3.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Fairwaymarking</td>
<td>8</td>
<td>4.6</td>
<td>-</td>
<td>-</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Written information on board</td>
<td>9</td>
<td>4.7</td>
<td>4.2</td>
<td>-</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>Pilotage</td>
<td>10</td>
<td>4.5</td>
<td>4.2</td>
<td>-</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Exemption certificates</td>
<td>11</td>
<td>3.3</td>
<td>3.4</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>VTS</td>
<td>12</td>
<td>4.7</td>
<td>4.4</td>
<td>-</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>SAR</td>
<td>13</td>
<td>4.6</td>
<td>4.4</td>
<td>-</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Salvage vessel (WAKER)</td>
<td>14</td>
<td>4.2</td>
<td>4.0</td>
<td>-</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>GMDSS</td>
<td>15</td>
<td>4.2</td>
<td>3.8</td>
<td>-</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>NEREUS</td>
<td>16</td>
<td>4.4</td>
<td>4.0</td>
<td>-</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Legislation</td>
<td>17</td>
<td>4.9</td>
<td>4.5</td>
<td>3.6</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* 1 = total disagreement, 5 = total agreement
Table 3.4 – Means of Responses to Statements Related to Tactics

<table>
<thead>
<tr>
<th>Tactic</th>
<th>Means over respondents *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>as a good idea</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Implement a new routing system for the Westerscheilde</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Vessels carrying hazardous goods do not use the Oostgat</td>
</tr>
<tr>
<td>1.2.5+1.1.6</td>
<td>No fishing or recreational vessel allowed in TSS</td>
</tr>
<tr>
<td>-</td>
<td>Replace “sector lights” with RACONs in the Westerscheilde</td>
</tr>
<tr>
<td>3.2.1A</td>
<td>Remove 50% of the buoys that mark the safe fairways</td>
</tr>
<tr>
<td>3.2.1B</td>
<td>Remove all the buoys that mark the safe fairways</td>
</tr>
<tr>
<td>3.2.6</td>
<td>Shut down nine lighthouses</td>
</tr>
<tr>
<td>5.1.2</td>
<td>All vessels (under certain conditions) are piloted by remote pilotage</td>
</tr>
<tr>
<td>5.1.1+6.1.1</td>
<td>Implement “Differential navigational support”</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Use English as the official communication language</td>
</tr>
<tr>
<td>6.2.3</td>
<td>Require transponders on board for ship-shore data communication</td>
</tr>
<tr>
<td>6.3.2</td>
<td>Elaborate the concept of Vessel Traffic Management Information Services</td>
</tr>
<tr>
<td>7.2.2</td>
<td>Locate helicopters in a central place in the North Sea</td>
</tr>
<tr>
<td>8.3.1</td>
<td>Double the salvage vessel capacity</td>
</tr>
</tbody>
</table>

* 1 = total disagreement, 5 = total agreement

Figure 3.4 – The Means of Responses within Stakeholder Groups Related to the Routing Tactics (1= total disagreement, 5 = total agreement).

For the cost-effectiveness analysis, the non-risk related acceptance of a tactic was summarized by the use of a single indicator. We assigned a high stakeholders’ acceptance (+ +) to a tactic if, on average, all stakeholder groups agreed that the tactic is a good idea. A tactic was assigned a slight acceptance (+) or unacceptance (-) if there were differences among the average responses of the stakeholder groups (on average, some stakeholder groups agreed with the presented statements and some groups did not). For example, on average Tactic 1.1.1 was thought to be a good idea, but it is assigned only a slight acceptance (+) because pilots disliked the tactics as can be seen in Figure 3.4. The indicators for the fourteen tactics are summarized in Table 3.5. These indicators were used in the cost-effectiveness analysis to describe the stakeholders’ acceptance of the tactics.
<table>
<thead>
<tr>
<th>Tactic number</th>
<th>Tactic description</th>
<th>Stakeholders' acceptance</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>Implement a new TSS to the Westerschelde</td>
<td>+</td>
<td>Pilots disagreed that the tactic is a good idea.</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Vessels carrying dangerous goods in bulk are not allowed to use the Oostigat channel</td>
<td>+</td>
<td>Pilots disagreed that the tactic is a good idea.</td>
</tr>
<tr>
<td>1.2.5 + 1.2.6</td>
<td>No fishing allowed in TSS and no recreational vessels allowed in TSS, combined with mandatory cross-over areas, entrances to, and exits from lanes.</td>
<td>++</td>
<td>Note: many stakeholders thought that the tactic would not be practical to use although it would increase safety and would be a good idea.</td>
</tr>
<tr>
<td>3.2.1.A</td>
<td>Remove 50% of the buoys used as reference marks.</td>
<td>-</td>
<td>Note: In the survey, the definition of this tactic did not include Tactic 3.1.4: increase the visibility of buoys.</td>
</tr>
<tr>
<td>3.2.1.B</td>
<td>Remove all the buoys used as reference marks.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3.2.6</td>
<td>Shut down nine lighthouses</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5.1.2</td>
<td>All vessels are piloted by remote pilotage (excluding vessels carrying hazardous goods)</td>
<td>-</td>
<td>Active waterway users and professional on shore agreed that the tactic is a good idea. On average, all the stakeholder groups agreed that a tactic decreases safety.</td>
</tr>
<tr>
<td>5.1.1 + 6.1.1</td>
<td>&quot;Differential navigational support&quot; (Implement tailor made pilotage)</td>
<td>-</td>
<td>Active waterway users and professional on shore agreed that the tactic is a good idea. On average, all the stakeholder groups agreed that a tactic decreases safety.</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Use English as official communication language</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>6.2.3</td>
<td>Require transponder on board for ship-shore data communication</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>6.3.2</td>
<td>Elaborate the concept of Vessel Traffic Management Information Services (VTMIS)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>7.2.2</td>
<td>Locate helicopters in a central place in the North Sea</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>8.3.2</td>
<td>Double the salvage vessel capacity</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
4. Summary of the Results from POLSSS

In this section we present a brief summary of the results from the POLSSS study. Details about how these results were derived and how they should be interpreted were discussed in previous sections and, in more detail, in [Walker et al., 1998a] and [Pöyhönen et al., 1998]. Four categories of results are presented: (1) results by tactic category, (2) an overview of regional strategies, (3) stakeholders' risk acceptance, and (4) stakeholders' perceptions about the effectiveness of selected tactics and current traffic management measures. As already explained, the results from the cost-effectiveness analysis should be considered screening results. The analysis started with a large number of tactics and produced a small set of promising tactics. The set of promising tactics should now be subjected to more detailed analysis – including checks on feasibility, costs, and the underlying assumptions that were used in the analysis. After that, weights can be assigned to the different impacts in order to determine preferences among the tactics.

4.1 Results by Tactic Category

The tactic categories are described in Sec. 2.2. The tactics that were evaluated in the cost-effectiveness analysis are listed in Table 2.6. In the following paragraphs, we summarize the results of the cost-effectiveness analysis for each category of tactics. The list of promising tactics is presented in table 4.1. Specifically, a tactic is said to be promising if it could be expected to lead to an increase in safety (no matter how small) and/or a decrease in monetary costs (financial costs plus economic costs).

Routing tactics. All of these tactics are specific to a single region. For some tactics, their consequences for fishing vessels need further attention. Some of the tactics were unpromising. Some promising tactics will be difficult to implement (e.g., widening of lanes by 20% requires that locations of anchoring areas and platforms need to be changed).

Waterway marking tactics. These tactics are generally designed to reduce financial costs without reducing safety. The nature of the results for this category of tactics varies significantly by region. There are some promising tactics, but no general observations can be made.

Piloting tactics. The deep-sea piloting tactics reduce accidents, but are very expensive. The remote and “tailor-made” piloting tactics save money, but increase accidents and the impacts from accidents. There are differences among the piloting tactics in stakeholder acceptance. All piloting tactics are promising. A decision about implementing any of these tactics requires a careful consideration of the tradeoffs between the benefits and financial costs. One should also remember that some of these tactics cannot be implemented together – i.e., they are mutually exclusive.

Vessel traffic services (VTS) tactics. These tactics affect the collection of information relating to shipping traffic in a port area and the distribution of this information interactively to ships,
pilots, and/or other officials. All of the tactics in this category were found to be promising and have high stakeholder acceptance. Overall, this group of tactics was the most cost-effective and appears to offer some good ideas for improving the maritime traffic system.

**Search and rescue service (SAR) tactics.** All of the SAR tactics increase the search and rescue capacity to save human lives, and all of them have some positive impacts. Furthermore, stakeholder acceptance is very high for all SAR tactics. Thus, all of the SAR tactics are promising. However, some of them are very expensive.

**Contingency planning tactics.** The analysis was based on estimating the impacts of current salvage vessel WAKER. The tactics suggest that this vessel is either removed or another similar vessel is bought. The removal of the WAKER was found to be unpromising whereas the doubling of the WAKER capacity was found to be promising. However, although the doubling of the capacity has some positive environmental impacts and is thus promising, it is very expensive and the savings in accident costs are much less than increase in financial costs.

### 4.2 Strategy Design Results

A strategy is a sensible combination of promising tactics. We identified one strategy for each region. Table 4.1 shows the strategy that was specified for each region. After the detailed analysis of the screening results is carried out, the suggested strategies should be reviewed.

Survey I focused on stakeholders’ risk acceptance. Among the general conclusions from the survey was that the stakeholders do not find the current risk situation acceptable, and preferred to increase the acceptability of the current situation through decreasing risks instead of increasing benefits. Relating these general conclusions to the regional strategies shown in Table 4.1, we can make some inferences about the stakeholders’ opinions of the strategies.

- **Regional strategies for all regions besides Westerschelde/East and Waddenzee.** Impact by impact (except for financial costs), each of these regional strategies improves the current situation or leaves it the same. Based on the survey results, the stakeholders did not find the current combination of risk and benefits acceptable. In the stakeholders’ opinion, the situation should be improved by increasing safety. These results indicate, therefore, that the strategies for these regions would be highly acceptable to the stakeholders.

- **Regional strategies for the Westerschelde/East and Waddenzee.** These regional strategies would introduce cost savings, but they would result in some decreases in safety or in the environmental situation (during the first time period in Westerschelde/East and for both time periods in the Waddenzee). These decreases in safety would not be acceptable to the stakeholders. The survey results say that financial savings should not compensate decreased safety or increased environmental damage. During the second time period, the Westerschelde/East strategy leads to an improved situation, which would make it acceptable. In both these regions, a strategy component including only the VTS tactics would lead to an improved situation with respect to all impacts besides financial costs.
<table>
<thead>
<tr>
<th>Promising Tactics/ Strategy Components</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open sea</td>
</tr>
<tr>
<td>1.1.1 (Implement a new TSS to Westerschelde.)</td>
<td></td>
</tr>
<tr>
<td>1.1.4 (Implement a new TSS between Maaswest inner and Maaswest outer)</td>
<td></td>
</tr>
<tr>
<td>1.2.5+1.1.6 (No fishing or recreational vessels are allowed in TSSs. Combined with mandatory cross-over areas, entrance to, and exits from lanes.)</td>
<td></td>
</tr>
<tr>
<td>1.3.3 (Use different lanes for different types of ships.)</td>
<td></td>
</tr>
<tr>
<td>1.3.4 (Widening of lanes by 20%.)</td>
<td></td>
</tr>
<tr>
<td>3.1.6 (50% of buoys with a light are replaced by buoys without a light)</td>
<td></td>
</tr>
<tr>
<td>3.2.1.A + 3.1.4 (Remove 50% of the buoys used as reference marks) or 3.2.1.B (Remove all the buoys used as reference marks, only for the time period 2004 - 2010)</td>
<td></td>
</tr>
<tr>
<td>3.2.6 (Shut down nine lighthouses)</td>
<td></td>
</tr>
<tr>
<td>5.1.1 + 6.1.1 (Implement Tailor-made Pilotage or 5.1.2 All vessels are piloted by remote pilotage, only for the time period 2004 - 2010)</td>
<td></td>
</tr>
<tr>
<td>5.2.1 and 5.2.2 (Make deep-sea pilotage required for ‘sub-standard’ ships and vessels carrying hazardous goods)</td>
<td></td>
</tr>
<tr>
<td>5.3.1. (Use English as official communication language.)</td>
<td></td>
</tr>
<tr>
<td>6.1.3 (Ship domain approach is used when vessels enter or leave harbors), 6.2.3 (Require transponder on board for ship-to-shore data communication) and 6.3.2 (Elaborate the concept of VTMIS.)</td>
<td></td>
</tr>
</tbody>
</table>

* = Tactic or Strategy Component is included in the strategy for region
4.3 Results from Survey I

Survey I showed that, in general, the respondents did not find the current risks in the POLSSS regions acceptable. For all risk dimensions -- number of accidents, environmental damage, economic damage, and human victims -- the majority of respondents did not accept the current situation. Also, for platform and oil tanker disasters, the majority of respondents did not accept the current situation. However, the majority of respondents accepted the current risks of a ferry disaster and a chemical/gas tanker disaster. Overall, the respondents favor attempts to decrease risks in the POLSSS regions.

As part of the survey, current risk levels were changed, and stakeholders were asked about their acceptance of the changed situation. Generally, the respondents preferred to increase the acceptability of the current combination of risks and benefits by decreasing the risks instead of increasing the benefits.

In general, the results from Survey I have the following implications for the cost-effectiveness analysis:

- Tactics that decrease risks instead of saving money are more acceptable.
- Tactics that decrease environmental impacts more compared to other impacts (e.g., economic consequences) are more acceptable.
- It is not acceptable to compensate an increased ecological damage by increasing benefits.
- It is acceptable to compensate the economic damage caused by accidents by increasing benefits.
- It is not acceptable to compensate an increased number of human victims by increasing benefits.

4.4 Results from Survey II

Respondents to Survey II generally agreed that all the current traffic management measures are practical, increase safety, are reliable, and are worth the costs. However, there were some differences among stakeholder groups. For example, for the system of exemption certificates, active waterway users, professionals on shore, and others agreed with the presented statements, whereas pilots generally disagreed with them.

Survey II showed that the tactics most preferred by respondents were to use English as the official language, to use transponders on board for ship-to-shore data communication, to increase the use of VTMIS, and to define a new TSS for the Westerschelde. The most disliked tactics were to remove buoys that are used as reference marks, and to shut down nine lighthouses. Almost all respondents thought that these were not good ideas and that they would decrease safety. There were some large differences in opinion among stakeholder groups. In particular, pilots disliked the piloting tactics whereas other groups thought that most of these tactics would be good ideas. Pilots also disliked changes in routing whereas other groups of stakeholders liked them more.
A. Non-RAND Europe/MSCN Persons Directly Involved in the POLSSS Project

Steering Group Members (Ministry of Transport, Public Works, and Water Management)

mr. K. Polderman  Head of the Traffic Management Division of the Freight Transport Directorate (DGG) (Chairman)
ir. M.G. Koopmans  Senior Policy Advisor for Traffic Management Instruments
J. Nipius  Senior Policy Advisor for the North Sea
D. van den Brand  Cargo and Risk Management Division
ir. G.H. Doornink  Head of the Transport Means Division
mr. Ir. J.W. Daamen  Rijkswaterstaat, Zeeland Directorate

DGG Project Group Members

drs. W. van Urk (Leader)
G.H. van der Ent
drs. H. van Heems
mr. L.P.M. van der Meij
ir. W.A. de Vries
DGG-POLSSS Communication: E.M. Jansen

Beheerdersgroep Members

A.P Margadant  Rotterdam Municipal Port Management
Capt. W.Ph. van Maanen  Rotterdam Municipal Port Management
A.D.F. Hiemstra  Port Management of Amsterdam
Lic. Capt. J.W.P. Prins  Rijkswaterstaat, Zeeland Directorate
Ing. K.H. Annema  Rijkswaterstaat, North Netherland Directorate
J. Ricken  Netherlands Coast Guard Center
J.H. Molenaar  Royal Navy, Den Helder

Experts

Fairway Marking Tactics

Financial costs
R. Aarts  DGG, Vaarwegmarkeringdienst

Tactic meeting
L. van Schaik  Rijkswaterstaat, North Netherland Directorate
F. M. Mol  Rijkswaterstaat, Zeeland Directorate
A. Verhaan  DGG
R.A.W. Pollen  DGG

Expert meeting
R. Behrend  Surall Marine
C.C. Glansdorp  Marine Analytics
C. de Jong  DGG (retired)
<table>
<thead>
<tr>
<th>Name</th>
<th>Company/Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.A. Kluytenaar</td>
<td>Kluytenaar Nautical Consult</td>
</tr>
<tr>
<td>C.M. Koomen</td>
<td>Regionale Loodsencorporatie Rijnmond</td>
</tr>
<tr>
<td>F. M. Mol</td>
<td>Rijkswaterstaat, Zeeland Directorate</td>
</tr>
<tr>
<td>G. van Santen</td>
<td>Scheepagentuur Dirkzwager BV</td>
</tr>
<tr>
<td>A. Verbaan</td>
<td>DGG</td>
</tr>
</tbody>
</table>

**Pilotage/VTS Tactics**

**Tactic meeting**
- M.G. Koopmans: DGG
- J. Schreuder: DGG

**Expert meeting**
- C.M. Koomen
- M.O. Betlem: Regionale Loodsencorporatie Rijnmond
- G. van Santen: Scheepagentuur Dirkzwager BV
- D. van Rooijen: Nederlandse Vereniging van Kapiteins ter Koopvaardij (NVKK)
- A. Keizer: NVKK (retired Nedlloyd)
- A.P. Margadant: Rotterdam Municipal Port Management
- P. de Korte: Rotterdam Municipal Port Management
- J. van de Veen: Port Management of Amsterdam
- G.H.H.B. Leuveling Tjeenk: Regionale Loodsencorporatie IJmond
- F.J. van Wijnen: NVKK
- R.J. Gutteling: NVKK
- G. Smilde: Regionale Loodsencorporatie Scheldemonden
- P.J. van Tilburg: Scheepv.dienst Westerschelde
- H.J.M. Adan: Scheepv.dienst Westerschelde
- R.E. Harders: Scheepagentuur Dirkzwager BV
- J.C. Ulrich: Captain, P&O Nedlloyd/NVKK
- P.P. Noë: Port Management Consultants
- R. van Gooswilligen: Nederlanse Loodsencorporatie
- J. Schut: Regionale Loodsencorporatie Scheldemonden
- J.W.P. Prins: Rijkswaterstaat, Zeeland Directorate

**Routing Tactics**
- R.A.W. Pollen: DGG
- J.W.P. Prins: Rijkswaterstaat, Zeeland Directorate

**SAR Tactics**

**Event tree meeting**
- J. Ricken: Netherlands Coast Guard Centre
- C.C. Glansdorp: MARine ANalyt...ics
- K. van Essen: Smit Tak
- J.A. van Schalkwijk: Netherlands Coast Guard Centre
- D. van Beelen: Netherlands Coast Guard Centre
- L. Vredevoeldt: TNO
- W.A. Vlakveld: DGG
- G.T. Koning: DGG, Scheepvaart Inspectie

**Tactic/Expert meeting**
- G.J. van der Meer: Netherlands Coast Guard Centre
- J.A. van Schalkwijk: Netherlands Coast Guard Centre
- R.A. Boogaard: Koninklijke Nederlandse Redding Maatschappij
- D. Eikelenboom: Royal Navy
- J. Ricken: Netherlands Coast Guard Centre
### B. Sample Scorecard

#### Rotterdam / Outside, Year 2000

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Total number of all accidents</td>
<td>number/year</td>
</tr>
<tr>
<td></td>
<td>Fatalities per km</td>
<td>prod/person_km</td>
</tr>
<tr>
<td>Environment</td>
<td>Total oil spills</td>
<td>m³/year</td>
</tr>
<tr>
<td></td>
<td>oil spills</td>
<td>m³/year</td>
</tr>
<tr>
<td></td>
<td>Total spills</td>
<td>m³/year</td>
</tr>
<tr>
<td></td>
<td>Total spills</td>
<td>m³/year</td>
</tr>
<tr>
<td></td>
<td>Large Ecosystem Risk</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Medium Ecosystem Risk</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Low Ecosystem Risk</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Non-ecological Risk</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Total emissions of CO₂</td>
<td>ton/year</td>
</tr>
<tr>
<td>Economic</td>
<td>Total operational spills of oil</td>
<td>m³/year</td>
</tr>
<tr>
<td></td>
<td>Cleaning costs</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Loss of income</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Repair costs</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Costs of shipping-miles</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Dredge costs</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Total costs from casualties</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Ferry - Ship</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Patents per km</td>
<td>prod/person_km</td>
</tr>
<tr>
<td></td>
<td>Societal risk (more than 10 deaths)</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Societal risk (more than 100 deaths)</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Chemical/Oil tanker - Ship</td>
<td>area within 10 km²</td>
</tr>
<tr>
<td></td>
<td>Oil tanker - Ship</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Oil spill more than 3000 m³</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Oil spill more than 10000 m³</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Number of oil slicks per incident</td>
<td>number</td>
</tr>
<tr>
<td></td>
<td>Cleaning costs</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Slip - Platform</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Individual risk (average of top 5)</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Societal risk (more than 10 deaths)</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Societal risk (more than 100 deaths)</td>
<td>probability</td>
</tr>
<tr>
<td></td>
<td>Slip - Harbor entrance</td>
<td>probability</td>
</tr>
<tr>
<td>Other</td>
<td>Stakeholder acceptance</td>
<td>qualitative</td>
</tr>
<tr>
<td>Financial</td>
<td>Investment cost</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Operating costs</td>
<td>MNLG/year</td>
</tr>
<tr>
<td></td>
<td>Change in parents risks</td>
<td>changes/period</td>
</tr>
</tbody>
</table>

#### Risk Factors

- **Safety**: Total number of all accidents, Fatalities per km
- **Environment**: Total oil spills, oil spills, Total spills
- **Economic**: Total operational spills of oil, Cleaning costs, Loss of income, Repair costs, Costs of shipping-miles, Dredge costs, Total costs from casualties
- **Chemical/Oil tanker - Ship**: Area within 10 km²
- **Oil tanker - Ship**: Oil spill more than 3000 m³, Oil spill more than 10000 m³, Number of oil slicks per incident, Cleaning costs
- **Slip - Platform**: Individual risk (average of top 5), Societal risk (more than 10 deaths), Societal risk (more than 100 deaths)
- **Slip - Harbor entrance**: Probability
- **Financial**: Investment cost, Operating costs, Change in parents risks
Bibliography


