Comet. A Comprehensive Methodology for Supporting Telematics Investment Decisions
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COMET
A COMPREHENSIVE
METHODOLOGY
FOR SUPPORTING
TELEMATICS INVESTMENT
DECISIONS
ROGER DEMKES

Telematica Instituut,
On top of technology.

This publication is part of Telematica Instituut's Fundamental Research Series. Telematica Instituut is a unique co-operative venture involving businesses, scientific research institutions and the Dutch government, which carries out research into telematics, a field also known as information and communication technology (ICT). The institute focuses on the rapid translation of fundamental knowledge into market-oriented applications such as electronic business practice, electronic co-operation and electronic data retrieval. We are also involved in the development of middleware. In a financial, administrative and substantive alliance, the parties involved work on a joint mission, namely the development and application of high-quality telematics knowledge. By combining forces in an international network of this kind, we will be in a better position to deploy the opportunities of telematics so that ICT can make a contribution to strengthening the innovative capacity of business and industry. In addition, telematics will fundamentally change and facilitate our way of living, working and even spending our leisure time. In all of these activities, technology remains the servant of man: On top of technology. The Dutch government also recognises the importance of information and communication technology, and awarded Telematica Instituut the title leading technological institute.

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Comet
A Comprehensive Methodology for Supporting Telematics Investment Decisions

Roger H.J. Demkes

Enschede, The Netherlands, 1999

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COMET
A COMPREHENSIVE METHODOLOGY FOR SUPPORTING TELEMATICS INVESTMENT DECISIONS

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Katholieke Universiteit Brabant,
op gezag van de rector magnificus,
prof.dr. F.A. van der Duyn Schouten,
in het openbaar te verdedigen ten
overstaan van een door het college voor promoties
aangewezen commissie in de aula van de Universiteit
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door
Roger Hendrikus Joannes Demkes
geboren op 6 maart 1970
te Emmen
Promotor: prof.dr. P.M.A. Ribbers
Co-promotor: dr.ir. P.H.W.M. Oude Luttighuis
Preface

This book is the result of a venture that started six years ago. If you would have told me in 1993 that the research would finally end in 1999, I would not have believed you. Also, I most likely would not have started in the first place, although I was very keen on doing a research of PhD quality.

My interest in research surfaced in the last years of my study at Groningen University and I was and am grateful that the Telematica Instituut offered me the opportunity to start a PhD research.

Back then, everything was new to me: the institute was just established, my colleagues were new, as well as the field of telematics research. This was certainly a challenging environment for starting exploring the new field of telematics assessment and telematics investment appraisal. Yet, I sometimes wished I had liked a bit more organisational structure.

As you might have seen, the cover of this book contains, besides the title, just one name, maybe suggesting that only one person worked on the results presented in this book. This is far from reality. In fact, many people have contributed in one way or another.

I started my work in close co-operation with Pieter van der Veer. Building the foundations of our research together has certainly helped me in finding my way in the world of telematics.

Pieter and I were supported by Paul Oude Luttighuis. I am greatly indebted to Paul, who, as my direct supervisor at the Telematica Instituut, always challenged me to dig deeper in a certain topic. Next, he ‘forced’ me to structure, not only my work, but also my thoughts. It certainly has improved the work substantially.

Piet Ribbers stepped into the process as thesis supervisor in the third year of the work. I am very thankful for that and for him keeping me on course during the last phases of the work.
Not only Paul and Piet offered guidance. In fact, I could make use of a whole team at the Telematica Instituut: Erik Wierstra, Dirk de Wit, Harm Bakker and Jeroen Schot. Thanks to you all.

Here, I also like to mention the essential input of the respondents in the cases, and of the experts who contributed to the expert session.

Other groups from my ‘Telematica Instituut period’ are the members of TAO, OTV and E-dispuut, who offered both a professional and a social platform which was very fruitful, as well as a lot of fun.

In 1998 I switched jobs and empirically found out what many people had warned me for: combining finalising a thesis with a full-time job is not very easy. Fortunately, my colleagues at TNO Inro, in particular in the Department of Logistics were of great help. Their continuous interest has certainly increased the speed of finishing this work.

I have to make up to a lot of friends and relatives, in particular to Olaf Tettero and Gerard van Calcar, who often had to hear my lame excuse ‘sorry, working on my thesis’. Thanks for your patience and support.

Finally (and perhaps traditionally), I want to thank my parents, who, with their love and ceaseless moral support, stimulated me to continue and gave me the confidence that I could finalise this thesis. Mom, Dad, thank you very much!

Roger Demkes

Delft, the Netherlands, October 1999
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Introduction

This book presents a methodology for supporting decisions on telematics investments. It describes the methodology itself, the steps we have taken in designing it, its theoretical foundations and its practical starting points.

In this chapter we first give a sketch of the problem area in section 1.1. In section 1.2 we present and elaborate our research objective, followed by the main requirements to the methodology in section 1.3. The research approach is described in section 1.4, followed by an outline of this book in section 1.5.

1.1 Problem sketch

Organisations find themselves in fast changing business environments. Competition in nearly every market is becoming more severe and often more international and even global. Customers become more demanding in terms of expected product quality, product versatility and service. Competitive strategies should be adapted to this. In many markets, a shift takes place from mass production to mass customisation or even to production-to-order (Luftman et al. 1993). At the same time, the impact and importance of telematics in current business practice is large and still growing. From a technical perspective, telematics comprises information and telecommunication technology (IT/ICT). We however define it from an application perspective, as follows:

Telematics is the support of people and/or processes through the integrated application of information- and telecommunication technology.

Telematics facilitates information processing, storage and exchange both within and between organisations. This can improve and extend the interaction between people and/or processes. Moreover, telematics can
relax the constraints of time and place. Telematics has a large potential impact on organisations and their stakeholders and many organisations are already highly dependent on telematics. Currently, organisational borders are crossed, redefined or even disappearing by the use of telematics, and inter-organisational co-operation more and more depends on telematics.

Telematics also requires large and growing sums of money, which makes the financial aspects a manifest management issue (see also Willcocks, 1996). Unfortunately, adequate assessment by decision-makers of the merits and possibilities of telematics investments for their own organisation falls behind on the fast growing opportunities of telematics. Decision-makers report on having difficulties in estimating and evaluating benefits and costs (Willcocks and Lester, 1996). Therefore, organisations are uncertain and question whether these investments will actually pay off.

This issue leads to ongoing debates, not only in academic literature, but also in business press. Example 1.1 gives some (translated) titles of recent articles in the Dutch Automatisering Gids. The returning themes in all articles are the questions whether and how IT/ICT contributes to value creation and by what methods the contribution can or should be measured.

<table>
<thead>
<tr>
<th>Example 1.1 Titles of some recent articles in Automatisering Gids related to costs and benefits (assessment) of IT and ICT</th>
</tr>
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<tr>
<td>- ‘Cost-benefit analyses are deliberately omitted’ (AG, 1998a)</td>
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<tr>
<td>- ‘Industry laconic about IT costs’ (AG, 1998b)</td>
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<tr>
<td>- ‘Return of IT can be calculated’ (AG, 1999a)</td>
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<tr>
<td>- ‘Return of IT not always properly visible’ (AG, 1999b)</td>
</tr>
<tr>
<td>- ‘Managers fiercely believe in the importance of IT’ (AG, 1999c)</td>
</tr>
<tr>
<td>- ‘Management focuses too much upon the cost-side of ICT’ (AG, 1999d)</td>
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</table>

Telematics has proven to be a complex investment object. This complexity is mainly caused by the fact that it combines a range of complicating aspects. Examples of these telematics aspects are given Table 1.1.

<table>
<thead>
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<th>Table 1.1 Telematics aspects</th>
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<tr>
<td>- Telematics integrates technologies</td>
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<tr>
<td>- Telematics developments evolve autonomously and rapidly</td>
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<tr>
<td>- Telematics solutions integrate with business processes</td>
</tr>
<tr>
<td>- Telematics integrates investments</td>
</tr>
<tr>
<td>- Telematics integrates organisations</td>
</tr>
<tr>
<td>- Telematics costs and benefits are difficult to assess</td>
</tr>
</tbody>
</table>

The various aspects and their consequences are discussed in the consecutive sections.
1.1.1 Telematics integrates technologies

As given in Definition 1.1, telematics integrates telecommunication technology with information technology (IT). Contribution of technology stems from various technology domains, such as:
- network technology
- mobile technology
- database technology
- multimedia technology
- Electronic Data Interchange (EDI) technology
- hardware and software technology in general, etc.

Adequate assessment of telematics investments requires some understanding of these technologies, the way they interact and how they contribute to the application.

1.1.2 Telematics developments evolve autonomously and rapidly

A major problem for organisations is that developments of telematics follow a very fast pace (Deitz, 1997). This complicates innovation strategies, because they need to be matched and tuned to new circumstances. Also, this severely shortens the investments’ economic life cycles. Standards and standardisation issues severely lag behind on technological developments so that the variety of choice is enormous and opaque. The pace of evolution also shortens the time available for gaining experience with particular technologies in business sectors or individual organisations. These implications place user organisations for the difficult task to choose telematics solutions from a very rapidly changing set of possibilities, with considerable risk of making wrong choices.

1.1.3 Telematics solutions integrate with business processes

Telematics investments are part of a business case, which combines investments in organisation and processes with investments in supporting technology. Also, telematics is spread throughout many business processes and shows close inter-relationships with those processes. This enlarges the complexity and the need for co-ordination. Assessment (ex ante) and evaluation (ex post) of telematics investment in isolation is therefore not possible (and should actually not be pursued).

1.1.4 Telematics integrates different investments

Different telematics investments are related. Often, one investment enables or facilitates another. Hence, part of the benefits of an investment consists of the power to enable other investments. Some investments may not even pay off if their enabling power is not taken into account. This holds in
particular for generic investments, like in ICT-infrastructures, which facilitate specific investments, such as in applications.

1.1.5 Telematics integrates organisations

Telematics typically crosses boundaries of individual business processes, departments and organisations. This offers many opportunities for tighter working relationships and new forms of co-operation. At the same time it may impact the way processes within and between organisations are co-ordinated, organised, and related. For instance, the governance structure may change from hierarchy (the firm) to market, or vice versa. It can also be that traditional structures are replaced by electronic ones (Malone et al. 1987). New organisational forms, such as the virtual enterprise, are enabled (Fulk and DeSanctis, 1995). Because of these changes in organisational boundaries, vested business routines need to change.

A complicating consequence of the inter-organisational nature of telematics is that agreement on the division of costs and benefits may become a major issue, because inter-organisational decisions usually have to be taken in the context of distinct objectives.

1.1.6 Telematics costs and benefits are difficult to assess

In practice, organisations frequently have little notion of the impact of the use of a telematics application on their organisation or the organisational network in which they operate. This problem has two levels. First, we see that decision-makers do not know which effects of the investment occur and should be estimated, partly because telematics effects occur beyond the scope for which the investment was intended. Related to this is the question when effects occur. In other words, the cash flow profile of a telematics investment is difficult to project.

Second, we see that decision-makers have difficulties in determining how these effects should be estimated, because the effects do not occur in a uniform and straightforward form. Any investment will generate a mixture of tangible and intangible effects.
1.2 Research objective

In the previous section we elaborated on problems related to telematics investment decisions. From this problem sketch we conclude that few investments combine so many complicating aspects as telematics investments do. This leads to our research objective:

The development of a comprehensive methodology for supporting telematics investment decisions.

A methodology can be seen as a collection of postulates, rules, and guidelines that provide a standard and proven process to follow. It should contain the following elements (Robson, 1997):

- A structure that gives guidance on what to do, and when to do it,
- A definition of techniques to do what needs to be done,
- Advice on how to manage the quality of the results, and preferably tools to automate the process.

The methodology can use alternative methods to achieve the overall aim and alternative tools to support those techniques.

1.2.1 Research questions

Our methodology must meet certain requirements, which have to be clear before development can start. At least, we need insight into the problem field as described in literature and as experienced in practice. Hence, we need insight into the theory and practice of investment decision-making. Furthermore, insight into current developments to cope with the problems sketched is necessary. An overview of existing support methods is needed.

The issues to be addressed before a methodology can be constructed are translated in the following research questions:

1. What form and structure does the (telematics) investment decision process have?
2. Which needs and wants do decision-makers have for support of their investment decision process?
3. What support methods exist and are useful for telematics investment decisions?
4. What aspects of the telematics investments should be taken into account in the decision process?

The research questions indicate that this study will be explorative in nature.
1.2.2 Relevance of this study

Is it necessary to develop yet another method to support decisions on telematics investments? Many already exist.

Chapter 5 will show that most of these focus on one aspect of the investment and fail to satisfy all important requirements. Therefore, before designing an outline of the methodology, we first need to come to a comprehensive overview of requirements which a decision support method for telematics investments should meet.

By identifying flaws in current methods and theory, we can determine requirements for the methodology. Capital budgeting literature, for example, assumes that alternatives to meet objectives are already given and gives no hints on how these alternatives in practice should be developed (cf. Bierman and Smidt, 1993). Outlining the methodology based upon the requirements should present decision-makers guidelines to improve the complete decision-making process. We follow Ansoff (1968), who drew attention to the process of strategic planning and presented general guidelines for structuring decision processes. We assume that a structured methodology can help in improving this process of decision-making.

We aim at combining (parts of) existing methods with newly developed methods under the expectation that this leads to a better support for the entire decision-making process.

COMET

Throughout this book we will use the term COMET as an abbreviation of ‘Comprehensive Methodology’.

1.3 Main requirements to COMET

Given our research objective, we can already derive several main requirements for COMET from the problem sketch of section 1.1. General requirements are stated in sections 1.3.1-1.3.7 (see also Demkes et al. 1998). Each of the requirements will be elaborated on in subsequent chapters.

1.3.1 COMET should treat telematics as part of a business case

In situations in which the telematics investment is part of a larger set of investments, it should not be treated in isolation, while it is hardly possible to trace effects back to just a part of the business case. COMET should treat a coherent set of investments as a whole, be it in a structured and step-wise fashion.
1.3.2 **COMET should permit the combined assessment of consecutive investments**

Many telematics investments find part of their benefits in their enabling character for consecutive investments. Sometimes, these investments even cannot be justified without recognising this enabling power. Therefore, COMET should permit to take into account the (effects of) the consecutive investments when assessing the investment under consideration.

1.3.3 **COMET should be inter-organisational**

The inter-organisational aspect of telematics investments has two sides. First, the object of the decision, that is, the investment itself, involves an inter-organisational telematics application, which means that its effects spread over different organisations. Second, the decision process will, at least for a part, be inter-organisational. Hence, COMET must allow for

- inter-organisational *co-operation* in the decision process. COMET should therefore not only have an economic perspective on the investment, but also focus upon the political and structural aspects of organisations (i.e. the *process* aspect of decision-making should also be supported).

- inter-organisational *description* of telematics investments. If such investments are described from the viewpoint of a single organisation, there is considerable risk of sub-optimisation.

- inter-organisational *assessment* of telematics investments. COMET should identify overall effects as well as effects for the individual stakeholders.

To meet these requirements we approach the inter-organisational setting with a business process view next to an organisation view. The business process view forces to analyse the processes which are affected by the investment, providing a more detailed insight into the effects of the investment.

1.3.4 **COMET should support estimation of all important effects**

COMET should take into account major aspects related to implementation of telematics.

A tough problem is that some potential costs and benefits are not measurable using traditional financially based evaluation techniques. Examples are increasing or decreasing job satisfaction, gaining competitive advantage, improved internal/external communications, etc. An approach to deal with this may be the use of multi-criteria methods.

Next to the difficulty in financially quantifying telematics effects, the implications of telematics often reach beyond the immediate context of investment, which determines the scope of analysis. We name these implications as *secondary effects* (see chapters 3 and 7). Secondary effects can
be substantial and should be taken into account. When alternatives are generated, all business processes in the inter-organisational setting which are influenced have to be taken into account.

1.3.5 **COMET should be comprehensive**

For the support of telematics investment decision-making many methods have been developed. SWOT analysis (see Robson, 1997) and the strategic option generator (Wiseman, 1994) are examples of methods supporting setting of objectives. Scenario development is often suggested to find alternatives to fulfil the objectives (Van der Heijden, 1996). For assessment of investments, an often-used classification recognises four groups of methods: financial methods, multi-criteria methods, ratio methods and portfolio methods (Berghout and Renkema, 1994).

The above mentioned methods either apply to objective setting, alternative generation, or assessment, which are only part of the entire decision process (Demkes, 1997). This makes the transfer of results from one step in the decision process to another problematic. COMET should deliver support along the lines of a decision-process model and should support all steps in the decision-making process and its components should fit to each other.

1.3.6 **COMET should be structured**

COMET should have explicit structure in order to reach explicit awareness of the alternatives available, the arguments used, and the choices made. Structuring also increases the quality of the decision process, because it encourages decision-makers to clearly state their considerations. It furthermore raises the level of control over the decision process and offers a guideline for inter-organisational decision-making, while such co-operation always requires more explicit structures. Finally, it enables to document and preserve the process and the choices made for later consultation. As a first structuring step, COMET will be divided into modules, each supporting part of the decision process. This will make the different steps to be taken in the decision process explicit.

Note that structuring along the lines of the decision process does not call for a top-down approach to the decision process. The structure does not prevent ‘tinkering’ in the organisation: initiatives can be taken anywhere (Ciborra and Jelassi, 1994). While the decision process is cyclic in nature, bottom-up initiatives can be fitted in.
1.3.7 Scope of COMET

The starting point to work with COMET will not be in the earliest steps of the organisational decision processes, i.e. setting the mission statement or general strategy for the entire organisation. COMET should be applied in the cycles where the focus is on the development of the telematics strategy and their subsequent cycles. Eventually, decision-makers, the users of COMET, should judge the alternatives, matching the results of COMET's assessment with their own interest.

COMET should be broadly applicable. That is, it should apply to various types of telematics investments, and it should applicable in various business sectors.

1.4 Research approach

Our approach to develop COMET consists of two major steps: deriving the appropriate requirements and the actual design of the methodology.

Deriving requirements

The main type of research questions which can arise in research are: what, who, where, how and why. There are various methods to find answers to these questions: we can perform literature studies, cases, experiments, surveys, archival analysis, history, simulation and expert sessions (Yin, 1994). Not every method can be used to find an answer to all research questions. For some questions a certain method is a better strategy to find the answers than the others. For the “what” questions which are of an exploratory nature, an exploratory case study, surveys and archival analysis can be used. For the “who” and “where” questions, surveys, expert sessions and archival analysis seem to be more appropriate strategies than case studies. These strategies can be of use when the research goal is to describe the incidence or prevalence of a phenomenon or when it is predictive about certain outcomes (Yin, 1994). The “how” and “why” questions have an explanatory nature and can be investigated by using either case studies, simulation, expert sessions, histories or experiments.

As given in section 1.2, the major part of this study is exploratory in nature and our research questions are of the “what” and “how” type. For these type of questions we can use the case study as exploratory and explanatory mechanism. While we are not only interested in the practice of decision-making, but also in underlying theory, an approach using case studies will be amended by literature research.
Design of the methodology
The development of a methodology for supporting decisions on telematics investments can be characterised as a design study, aiming at changing and improving functioning of organisations. This is one main type of research as distinguished in management science. The other type is empirical-analytic research, aiming at description, explanation and prediction of phenomena in organisations.

In design studies, researchers can be actively involved in providing solutions for actual and possible problems in organisations. Instead of ‘spectators’, researchers may become ‘players’. A design study seeks to supply scientifically grounded common knowledge for the improvement of the actions of professionals in finding solutions to specific problems of an organisation (Van Aken, 1994). It aims at the development and realisation of proposals by which users can steer the organisation in the preferred direction. It is often impossible to give quantified predictions of the effects of the research product in practice. Other terms used for this type of research are applied or practical research (Van der Zwaan, 1990).

Steps to be taken
For deriving the requirements for the methodology and the actual design of the methodology we use a stepwise approach. This approach is given in Figure 1.1.

- As a first step (chapter 1), we formulate our research objective and our research approach, as described in this chapter. The research objective is based on choosing a problem from a ‘problem mess’ (Van Aken, 1994).
- In the second step (chapters 2 - 5), we conduct theoretical research, in parallel with explorative case research. The goal of the theoretical research is to gain insight into theory on decision-making, existing support methods for decision-making on telematics investments and to find a theoretical basis for COMET. We use explorative cases to gain insight into decision-making in practice and the problems which decision-makers are confronted with.
- In the third step (chapter 6), the analysis results of the second step are translated into propositions, which on their turn are validated with new case material. This step serves to find support from practice for the analysis results of step 2.
- In the fourth step (chapter 6), specific requirements are derived from the analysis results (in addition to the main requirements given in section 1.3. The requirements must lead to a solid basis for the design of the methodology.
- The fifth step (chapters 7 - 11) consists of the development of a first design of COMET, on the basis of the requirements.
In the *sixth step* (chapter 12), the first design of COMET is confronted with practice. For this first confrontation we will use a controlled situation, that is, the methodology is presented in an expert meeting. The experts should come from both practice and the academic world. After this confrontation, conclusions are derived and this research is concluded by presenting suggestions for a new research cycle, in which COMET should be applied in practice.

![Diagram](image)

**Figure 1.1** The design approach used

### 1.5 Outline of the book

The outline of this book is given in Figure 1.2. The book is divided in three parts. The first part, comprising chapters 2-6, focuses upon deriving requirements for the methodology. The second part describes a first design of COMET. The third part comprises the concluding chapter.

In chapter 2 we discuss theory on investment decision-making and present a decision process model. The modules of COMET will be built along the lines of the stages of this decision-making model. In chapter 3 we present the theoretical foundations of COMET. In chapter 4 several cases are analysed on telematics investment decision-making. For that, we use a framework based on the decision process model of chapter 2. Chapter 5 investigates what advantages and disadvantages can be found in existing decision support methods. The results of chapters 2-5 are summarised by
chapter 6, in which requirements for COMET are determined. In this chapter we introduce four new cases, intended to find support for our propositions. In chapters 7-11 we present a first design of COMET. Chapter 7 introduces the overall structure of COMET, whereas chapters 8-11 present the different parts of the methodology. Chapter 12 wraps up the research with a discussion of the results, comments on COMET from experts, several conclusions and directions for further research.
PART I – Requirements for the methodology
Chapter 2

Investment decision-making

Since COMET is intended to support decision-making on telematics investments, we first need to gain insight into the process of decision-making. Next to that, we need a structure of the decision process according to which the methodology can be constructed. We therefore discuss in this chapter theory on decision-making. In section 2.1 we present three views on decision-making. Section 2.2 introduces a decision-process model which forms the basis for the COMET modules. In the last section of this chapter, 2.3, we discuss inter-organisational co-operation and decision-making.

2.1 Decision theory

An organisation basically exists to fulfil certain goals of its stakeholders. Fulfilling the goals implies taking decisions by the management of the organisation. These decisions are numerous and can cover nearly all aspects of the organisation. Decision-making practice has been under careful scrutiny for many decades and from different perspectives (Miller et al. 1996). Broadly speaking, the following models of decision-making are in use:

- Rational and bounded rationality models.
- Political models.
- Chaos- and disorganised order models.

The rational and bounded rationality models are of a prescriptive nature; they explain how the decision-making process should be performed (not which objectives and/or aspiration levels should be pursued). The political and chaos models are of a descriptive nature; they try to explain how decision-making actually works in practice.

The rational model stems from the neo-classical paradigm. In this approach a decision-maker shows rational behaviour and strives for optimal
solutions for his problems. Decision-makers in the bounded rationality models show rational behaviour in a certain context and strive for satisfactory solutions. In political models, power and politics in the organisations are highlighted (which can be reflected in hierarchical relations, political coalitions and/or bargaining processes). The chaos models assume that the decision-making process is influenced by a large amount of (uncontrollable) factors. A famous example of a chaos model is the garbage can model (Cohen et al. 1972).

Each of these models will be briefly discussed in the following subsections to determine how they work and to what extent they can be incorporated in COMET. If not, we have to determine how COMET can be used when the conditions of a certain model apply.

2.1.1 The rational and bounded rational decision model

The models of rational decision behaviour and of bounded rational decision behaviour are related. The latter is developed in a reaction to the strict assumptions set by the former.

The rational model

In the neo-classical economic theory, the concept of the 'rational man' is developed. This concept has the following assumptions with respect to decision-making (March and Simon, 1992):

- The whole set of alternatives from which decision-maker will choose is known.
- Each alternative has a known set of consequences.
- At the start of a decision process, a decision-maker has a 'utility function' or a 'preference ordering' that ranks all sets of consequences from the most preferred to the least preferred.
- The decision-maker selects the alternative leading to the preferred set of consequences.

The model assumes that organisations scan all alternatives continuously and just as continuously adjust their portfolio of investments to changes in the pattern of alternatives. The model furthermore assumes that firms have accurate and complete information on the costs to be incurred and returns to be received from alternatives and that decisions are made on the basis of this information (Cyert and March, 1992). Given these assumptions, organisations seek optimal solutions. To find optimal solutions, organisations have a set of criteria making it possible to compare all alternatives. The optimal alternative is preferred, by these criteria, over the other alternatives (March and Simon, 1992).

The assumptions of rationality and optimal solutions are difficult to be met in practice. Decision-makers will never have all information available.
The model can be used for ‘programmable decisions’ and ‘well-structured problems’ (Renkema, 1996). Unfortunately, strategic telematics investments usually are complex and seemingly chaotic. Operational or tactical decisions are generally believed to be rational, at least to a higher degree than strategic decisions, which are less structured and more complex and involve more people (Vossen, 1996).

An advantage of the rational model is that it uses a logical and sequential approach. Decisions are made deductively by determining the objectives to be obtained, evaluating the potential alternatives based on the information at hand and choosing the optimal alternative. The model is simple and intuitive in nature (Lahti, 1996). Yet, because the model assumes that all the alternatives are given and that all consequences attached to each alternative are known, as well as that the rational man has a complete preference ordering for all possible alternatives, it puts many restrictions to the use in practice. Another disadvantage is that the model assumes that there are no intrinsic biases to the decision-making process. However, individuals involved in the process bring their own perceptions and mental models into such a situation (Lahti, 1996). Hence, intrinsic biases are inevitable and should be addressed.

The bounded rationality model

The model of bounded rationality relaxes the strict premises set to the decision process by the rational model. March and Simon (1992) point out that the decision-maker, being a human, is at best ‘subjectively rational’ and runs into his cognitive limits. This means that he is rational relative to some specified frame of reference and cannot overlook all possible alternatives or the entire problem, due to its complexity.

The decision-maker is bounded in three ways: he is limited by his mental skills, habits and reflexes; he is limited by the extent of knowledge and information he possesses; and by values he possesses which diverge from organisational objectives (Simon, 1957). Decision-makers base their decisions on incomplete information, and do not always properly respond to the information available, nor correctly interpret it. Due to the fact that the assumptions of the rational model can hardly be met in practice, adjustments have been made in the bounded rationality model. Probability distributions are introduced, and consequently, expected profit and utility replace profit and utility. Next to that, the assumption of infinite search has been replaced by a theory of search that recognises costs associated with searching. Hence, modern managers do not scan all alternatives nor do they have all information.

An alternative for the optimal search strategy, which can better cope with actual behaviour of decision-makers, can be found in the satisficing strategy. The satisficing strategy uses a set of criteria that describes
minimally satisfactory alternatives and the chosen alternative meets or exceeds all these criteria. With this strategy, the decision-maker searches for alternatives which comply with his level of aspiration (see also Briston and Liversidge, 1979). Therefore, the search (for alternatives) decreases as satisfaction (with the present course) increases.

2.1.2 The political decision model

The rational model and bounded rationality model do not take account of the role of power and political behaviour in the decision process (Miller et al. 1996). The political model sees decision-making as a game of power in which several (groups of) stakeholders try to gain the control over scarce resources. When a group gains control over the flow of resources, especially when this flow is scarce and crucial to the organisation, power will accrue to that group (Miller et al. 1996). Stakeholders often have conflicting interests in the organisation (for example, ownership and management of organisations are usually separated) and, hence, put conflicting pressures on management. These pressures cannot be ignored if effective action and internal harmony in the organisation are to be achieved (Crum and Derkinderen, 1981).

Another source of power in an organisation is the ability to deal with uncertainty. Coping with uncertainty is a major task in decision-making. While organisations are confronted with uncertainty stemming from relations with their suppliers, customers, competitors, banks, government agencies, etc., the group which is able to deal with these uncertainties on behalf of the others, is likely to attain power (Miller et al. 1996).

The political model takes account of the fact that decision-makers not necessarily show rational behaviour. In this model, behaviour of decision-makers in the decision process is based on their own needs and perceptions (Lahti, 1996). The decision process contains bargaining among decision-makers in order for each of them to try to get his ideas to be chosen. Next to that, the political model assumes that full information availability is highly unlikely. Having information available makes it possible to negotiate with other decision-makers, in which power positions and favouring certain groups over others becomes apparent. Information is often withheld to better position the decision-makers’ own needs. In hierarchically structured organisations, multiple organisational levels can be involved in the decision process. In this situation, internal politics, power struggles and different valuations of criteria tend to bias or pollute information flows (Crum and Derkinderen, 1981).

An advantage of this model is that it provides a representation of the subjective manner in which the real world often operates, and that it can minimise conflict. By identifying or acknowledging the fact that individuals
have their own biases and agendas which influences their behaviour, potential problems can be foreseen and minimised. Demonstrating the way the real world works is simultaneously a disadvantage, because the best solution or decision may not be chosen (presuming that there is a best solution). Besides, the nature of bargaining and manoeuvring can produce long-lasting and detrimental effects for the organisation (such as high social pressure in a group). Although power is a central theme in this model, a methodological problem related is the question how to conceptualise it, especially when it is employed covertly (Miller et al. 1996).

2.1.3 The chaos model

The chaos model provides a real-world representation of the non-rational manner in which decisions are often made in practice. In the model, unclear objectives and conflicting objectives, as well as human ignorance and error are significant parts of behaviour in organisations. Individual action may aim at the organisational goals, but also at quite different and wholly personal goals. Decision-makers' actions can be well adapted to their goals, but also poorly, because they are misinformed, lack information, or are unable to predict or compute the consequences of their behaviour. Often, their objectives are unclear, inconsistent and changing.

The chaos model can be found in organised anarchies: complex organisations of which the internal processes are difficult to understand, even for the people working in the organisation (Miller et al. 1996). The model is suitable for situations in which technologies are unclear, the amount of time and effort spent by the participants fluctuates and choices are inconsistent and not well defined (Lahti, 1996). Problems are worked on in given situations, but choices are made only when the combination of problems, solutions, and individuals allow the decision to happen (i.e. when they are in alignment). This often leads to the situation in which the alignment of the three occurs after the opportunity to make a decision regarding a problem has passed, or occurs even before the problem has been discovered. This model is descriptive, using it as a means to structure decision-making would not lead to the most efficient process of making decisions.

2.1.4 The basis for COMET

Our aim is to make COMET a structured methodology supporting all steps in the decision process. We thus need a model that describes all steps in a structured fashion. Although the chaos model may provide clear insight in daily decision-making, it offers too little structure to serve as a basis for COMET. Both the rational and bounded rationality models offer this possibility. Yet, the assumptions of the rational model are too tight for
practical purposes, making this model less suitable. We will use the concepts from the bounded rationality model as starting point. In practice, many problems are 'messy' or 'fuzzy', making it impossible to programme decision-making. Hence, although we suggest a structured approach, this does not imply that the whole decision process is fixed. The structure should be flexible enough to be adapted to particular circumstances. Besides, its structure should be such that it can make use of features of other models, when it appears that these models are more convenient to describe a certain situation.

The bounded rationality model does not explicitly take account of situations in which a group of decision-makers and stakeholders are involved (which holds in particular for inter-organisational decision-making). We will amend the bounded rationality concepts with concepts from the political model where necessary and possible.

In the next section the model will be further developed.

2.2 A decision process model

Investment decision-making is part of a larger process, notably the investment process. Basically, we can divide this process in three steps (see Figure 2.3). First, a problem or opportunity is encountered to which the organisation seeks an answer. Alternatives will be sought and assessed and a choice is made. Many iterations in the process can take place and different decision processes can be carried out in parallel. In the next step the implementation will take place. This implementation can be executed in many different ways, on which we will not elaborate. The third step is the actual use of the investment in operations. In this model we do not recognise a separate evaluation step, while evaluation should take place during each stage of the process (see also Willcocks, 1996).

![Figure 2.3 The investment process](image)

We will concentrate on the first step in the investment process, the decision process. Except for the chaos model, the decision models mentioned in section 2.1 recognise several general stages in the decision process: setting an objective, searching for alternatives, assessment of the alternatives and making choices. These stages are presented in a general model of the decision process in Figure 2.4.
In practice, the model is made operational in many different ways. The depicted model does not have a time dimension; it reflects dependencies between the different stages. The model given in Figure 2.4 only gives one decision cycle. The decision process in practice will consist of many cycles; the investment decision process involves taking many different decisions.

In practice, nesting of the decision process stages may take place: first, high level objectives, criteria and constraints are set, from which directions for solutions can be determined. On the basis of criteria and constraints, a choice for a direction is made. Then, a second decision cycle starts with a lower level (more concrete) objective and criteria which apply to that level, etc. In this way, decision-makers will deepen their insight into the opportunity or problem they face. When decision-makers are developing a strategy, they will always make a sequence of decisions (Luehrman, 1998b).

In the following we discuss each step in the decision cycle.

**Objective setting**

We define an objective as:

*An objective is a statement about the desired state of a particular system.*

A system can either be an organisation, a (logistics) chain or an organisational network.

The generic objective for a system is to establish continuity. This objective, however, is too general to give direction to the appraisal of investment alternatives (Euser, 1990). Euser sees the pursuit of profit as the regulating motivation of decision-makers for profit-generating companies. This pursuit is being used as an explanation of the behaviour of decision-makers. Yet, a certain profit target does not sufficiently explain decision behaviour. Factors such as politics, bargaining, hierarchical relations, emotions, and intuition also play a role. Besides, many not-for-profit organisations (like hospitals and universities) will have different regulating motivations in decision-making.

The organisational objectives represent what the organisation actually wants to establish with a particular investment. In the first stage of the decision cycle, the organisation will experience that the current situation is unsatisfactory and that the objectives aimed for have not been reached so far. In this part, decision-makers are 'appraising the challenge' (Janis and Mann, 1977): problem or opportunity recognition occurs and on the basis
of this recognition new objectives will be set or adjusted (i.e. the search for possibilities to fulfil the objective). The length of the objective setting stage severely depends on understanding of the opportunity or problem. External influences to the organisation are a major cause of the divergence of the current situation with the desired state (see also Cyert and March, 1992). External influences can be based on changing customer wishes and buying behaviour, intensifying competition, changes in legislation, etc. Decision-makers can have a passive or a pro-active approach towards developments in the organisation and the environment. With a passive approach, they react to changes and with a pro-active approach, they try to set the pace of the developments or actively steer the changes.

In the objective setting part of the decision cycle the decision criteria to which the alternatives must comply should also be set. We define a decision criterion as follows:

**Definition 2.2 Decision criterion**

A decision criterion is a concrete part of an objective, making measurement of the contribution of alternatives to the objective possible.

By choosing an clear set of criteria, the assessment and comparison of alternatives becomes easier. The first objectives generated can already point out (at a high level) what the alternatives should be able to solve. Decision criteria make the objective more operational. Setting of criteria consists of two parts: determining the criteria themselves and the values or targets which must be attained by the alternatives. The inputs for the criteria values are the effects caused by the investment. Hence, in order to determine the values of the decision criteria, the decision-makers should know which effect (values) will occur. We define an effect as follows:

**Definition 2.3 Effect**

An effect is a change in the existing situation caused by the investment alternative.

The set of decision criteria will consist of two types: the criteria that will be optimised, maximised or minimised and the criteria that have to be met anyway at a predetermined level. We refer to these latter criteria as constraints. A constraint very often used in practice is the (investment) budget. Alternatives must fit in the budget, or else they will not be accepted.

The result of this stage is a defined (set of) objective(s) with a set of decision criteria and constraints. If the objectives are more concrete, the direction in which a solution can be sought will be more clearly defined. A complicating aspect in decision-making is that objectives often change during the course of the process. Thus, an alternative that initially would be suitable for the objective, might suddenly become less useful or even useless. The question whether the alternative is satisfying for the objective
should become clear from the assessment, the implementation and post-
implementation evaluation.

**Alternatives generation**

In the next stage, alternatives will be generated as possible candidates to
fulfil the objectives. We define an alternative as follows:

*An alternative is a complex of interrelated investments (in telematics) for the
support of a (set of) activities.*

While we use the bounded rationality model as starting point, in the
alternatives generation stage satisficing approaches will be used to find the
alternatives. The activities in this stage will be influenced by the concrete
level of the objective and the amount of time and money (resources)
available to search for a solution. Alternatives generation can be executed in
many different ways: by market research, brainstorm sessions, hiring
external consultants, approaching technology suppliers, etc. The strategy for
the development of alternatives will depend on the amount of resources
available in the decision process. That is, the amount of search time,
capacity and budget will determine how many alternatives are generated and
how detailed they will be.

With respect to telematics, ideas should be generated about which
systems and applications will become important and how telematics can
support the organisation and its processes. Crum and Derkinderen (1981),
as well as Luehrman (1998b) argue to take into account future
consequences of current actions (alternatives), including the consequences
for organisational flexibility. Following this line, COMET should be able to
present the future consequences of current alternatives.

**Alternatives assessment**

In the assessment part, the alternatives are analysed and then compared on
the basis of the decision criteria set. In this part, the alternatives must be
confronted with the target values for the criteria. First, the changes (that is:
the effects) to the situation caused by the alternative should be estimated.
With appraisal of criteria, decision-makers relate the expected effects to the
criteria. The expected effects thus serve as input for the appraisal of the
criteria.

Precise measurement is almost always difficult and costly, and is rarely
essential. *If the differences between alternatives are so slight, it does not matter
whether the better one is chosen* (Oxenfeldt, 1979). What needs to be done is
to separate alternatives that are significantly different. Therefore, decision-
makers should be as clear and precise as possible in defining what they seek
to measure. They should dare to make unorthodox and crude
measurements when these are the best that can be obtained under the circumstances and refrain from measuring when the results will not alter their behaviour. This implies that it is almost inevitable that some error and inaccuracy in measurement occurs. Decision-makers should refrain from seeking precision for its own sake (Oxenfeldt, 1979).

In the assessment stage of the decision cycle, it may become clear that the decision criteria do not sufficiently provide insight into the alternatives. In that situation, new criteria might be added and (values of) existing criteria might be adjusted. Another possibility is the refinement of crude or high level criteria into criteria that can be more easily made operational. This leads to a new decision cycle. Causes for changes in the set of criteria are the availability of new information during the assessment stage, difficulties in assessing the alternatives by the criteria initially set, or because initially implicit criteria now become explicit.

A large amount of methods to support investment decisions is available and an even larger amount of criteria can be used for the assessment of various alternatives. However, organisations and human actors show a tendency towards methods which compare alternatives on a quantitative base or, more specific, on a financial base. From a practical point of view the decision-maker will often like to keep the set decision criteria as small as possible and limit it to one quantitative criterion.

IT-based tools such as Edialysis (see Hoogeweegen et al. 1995) and other decision support systems can be of use to improve the decision-making process, especially in the assessment stage. However, according to March and Simon (1992), the total impact has been limited, because the new tools mainly apply to situations that can be described without too much distortion in mathematical form, and for which numerical data appropriate to the formulation can be gathered. While this latter situation often not applies to strategic telematics investments, these tools are less useful for telematics investment decisions.

Choice

After various alternatives have been generated and assessed, a choice for an alternative can be made on the basis of the results of the assessment. We define a choice as follows:

Definition 2.5 Choice

A choice is a selection of and ultimately a commitment to execute an alternative.

In existing support methods there is often hardly a distinction between the assessment stage and the choice stage on the basis of that assessment. This is probably caused by the fact that the sequence of searching, assessing and choosing alternatives is processed in an iterative fashion. The assessment of
alternatives is used as a sieve. First, a crude comparison of alternatives is performed, followed by refined assessment(s) of the available alternatives.

According to Van Beek (1996) the degree of freedom of choice varies per situation. Some investments are mandatory (due to market situations, obligations towards customers or legislation). In this situation there is no freedom of choice. Obviously there is one alternative in which must be invested (hence, constraints in freedom of choice will also be reflected in the stages alternatives generation and assessment). At the other end of the spectrum are the investments for which full freedom of choice exists. One can think of entering new markets or creating new product lines.

Crum and Derkinderen (1981) point out that in situations in which more criteria are used, the most crucial part of the decision process is characterised as trading off the various criteria against each other. They suggest to preserve the essential multidimensional nature of the problem to the actual choice of an alternative.

We assume that decision-making involves more than one actor. Therefore, in each stage of the process, collaboration and negotiation occurs. This will be particularly apparent in the choice stage of the decision process. In a situation in which one individual operates, the choice is simple: the decision-maker chooses the alternative which is most appealing to him (satisfying his criteria). In the situation with more decision-makers, choice is far more complex, especially when the alternatives are assessed by using a set of criteria of which the relative importance from one criterion to the others is not fastened down (and hence, everyone can give his own interpretation).

When a choice is made, a new decision cycle may start, the implementation stage can start or the investment is disapproved and no implementation will take place.

**Quality of the decision process**
The decision process as sketched above is rather straightforward. Still, decision-making in practice usually is not as simple as given. Streng (1993) summarises some reported difficulties in decision-making in practice. The difficulties are related to the contents of the decision process and to the process itself:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Complexity and uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>The problem is ill-structured</td>
<td>Problems of estimating impact</td>
</tr>
<tr>
<td>Lack of clear, measurable objectives</td>
<td>Lack of sufficient information</td>
</tr>
<tr>
<td>Conflicting objectives and criteria</td>
<td>Time pressure</td>
</tr>
<tr>
<td>Miscommunication between the people involved</td>
<td></td>
</tr>
<tr>
<td>Lack of skills to determine what information is relevant</td>
<td></td>
</tr>
</tbody>
</table>
The purpose of the development of COMET is to prevent and to cope with the difficulties mentioned in Table 2.2.

Janis and Mann (1977) give some guidelines which decision-makers can use to determine whether the decision-making process is of good quality. Decision-makers should judge whether they have surveyed the full range of objectives to be fulfilled and the value implicated by the choice. They should also judge whether they have carefully studied a wide range of alternative courses of action and have carefully weighed whatever they know about the costs and risks of negative consequences that could flow from each alternative. They must have searched for new information relevant to further evaluation of the alternatives and have correctly assimilated and taken account of any new information or expert judgement to which they were exposed, even when the information or judgement does not support the course of action they initially preferred. Then they should have re-examined the positive and negative consequences of all known alternatives, including those originally regarded as unacceptable, before having made a final choice. Finally, they should have made detailed provisions for implementing or executing the chosen course of action, with special attention to contingency plans that might be required if various known risks were to materialise. We add to these criteria that decision-makers should have taken care of a sufficient basis and consensus among their fellow decision-makers and among those who are affected by the decisions.

2.3 Inter-organisational investment decision-making

Organisations are not closed systems without relations with their environment. They interact with their customers and suppliers and often co-operate with other organisations. In current business, some companies operate as one networked organisation or even as a virtual organisation. In these type of organisations, companies remain legally different entities, but may bring together several competencies, for example to reduce costs or increase overall flexibility (Wildeman, 1998). Hence, decision-making also often crosses the borders of the organisation. A myriad of reasons for cooperation exists. An organisation may be confronted with a certain problem or objective for which it independently cannot find a solution (see Wissema and Euser, 1988). Other reasons are to share costs and share risks, or to have access to complementary knowledge. Organisations may also strive to jointly serve a larger market or to jointly develop (industry) standards.

Consequently, investments and their results are often not restricted to within the borders of the organisation, and vice versa: organisations will experience the consequence of investments done by others. When other organisations are influenced by the results of the investment, they probably
want to be involved in the decision process or influence its outcome.
Various forms of co-operation exist between organisations. In Table 2.3 we
present forms of co-operative relationships which we found both in
literature and practice (Van der Vlist, 1988; Wissema and Euser, 1988;
Huyzer et al. 1992; Van Aken et al. 1997):

<table>
<thead>
<tr>
<th>Forms of co-operative relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Normal' customer-supplier relationship</td>
</tr>
<tr>
<td>Franchise, agency/dealerships and licensing</td>
</tr>
<tr>
<td>Co-makership/outsourcing and value-added partnership</td>
</tr>
<tr>
<td>Network organisations and virtual enterprises</td>
</tr>
<tr>
<td>Joint-ventures/strategic alliances</td>
</tr>
<tr>
<td>Participation and merger/take over</td>
</tr>
<tr>
<td>Industrial conglomerates (Japanese Keiretsu; Korean Cheabol)</td>
</tr>
</tbody>
</table>

The difference between the above forms of co-operation is based on
juridical definitions of the relationship and on the activities which are
jointly executed. Van der Vlist (1988) recognises three types of organisation
networks, based on their (inter)dependencies:
- Horizontal interdependence: organisations are competitors.
- Vertical interdependence: organisations sequentially follow each other in
  a supply chain.
- Symbiotic (or diagonal) interdependence: organisations offer
  complementary services to the market.
An organisation network consists of multiple organisations, which are
dependent on each other to reach certain objectives, which, in that context,
align their actions in some kind. They will most likely offer only that part of
their autonomy that is expected to be functionally necessary for the
attainment of the objectives (Wissema and Euser, 1988). Participating in a
network implies that the environment is no longer taken as given, but the
organisation is trying to use and partly control that environment.
Organisations in a network may become more dependent on each other,
but can also create a (shared) competitive advantage by the participation.
There will usually be a tension between the organisation network and the
individual participants, because the individuals may fear that the network
organisation will take over functions which are seen as part of the individual
organisation.

If multiple organisations jointly execute decision processes, agreements on
or alignment of objectives is necessary. In order to make the co-operation a
success, ideally, the involved organisations should assure that they all have a
common interest, no conflicting interests exist and that the interests of all
parties involved are all equally essential (Wissema and Euser, 1988; Van der
Zaal, 1997).

Besides agreement on the objectives, the process of decision-making may
be subject to discussion. In inter-organisational settings, the process likely
contains more explicit discussions, negotiation and bargaining than in single organisation decision-making. These activities may hamper the pace in which the decision process flows and delays can occur in the decision process. Examples of aspects which influence the process of decision-making are (Miles and Snow, 1992; Miller et al. 1996; Van der Zaal, 1997; Wildeman, 1998):

- A common goal with regard to ‘what’: the objective that needs to be established. A shared interest is seen as a critical success factor for inter-organisational co-operation and investments. The role of COMET is here to provide means to establish such an unambiguous mutual objective. The usefulness of the investment should be clear and evident to all participating organisations. In other words, a win-win situation for all parties is a critical success factor. COMET should at least be able to present the results of the investment for all parties.

- The tightness of the relationship: organisations which work more closely together, or are linked to each other by juridical structures will more easily develop joint investment initiatives.

- The intensity of the interaction (incidental - regularly/structured): if a relationship between organisations is regular, their willingness to jointly invest will be larger.

- Power structures in the relationship/organisational interdependence: in situations in which a certain organisation dominates its partners, or organisations are highly dependent on their partner, the dominating organisation will be able to push its ideas and can force its business partners to join its investment initiatives.

- Trust between the co-operating parties: if organisations do not trust their partners, they probably will not be willing to share resources or invest in cross-organisational structures.

- The organisational level at which the co-operative relation is established; strategic, tactic or operational: the higher the level of co-operation is, the more organisations will have the intention to join in investment initiatives.

- Different organisational units may look differently at external co-operation and their relation with external parties can be different: for example, the purchasing function may be shared between organisations at their purchasing market, whereas they fully compete with each other at the market where they sell their products.

Co-operation between the parties involved is crucial for success. How can COMET support this co-operation? Some aspects can be supported, like the establishment of a clear and unambiguous objective; other aspects can hardly or only indirectly be supported, like trust. These latter aspects are more important for the description of the context in which the methodology will be used. It is not likely that COMET, as a supporting methodology, will be of influence on these aspects.
We assume that the earlier organisations jointly execute stages of the decision process, the tighter the relationship will be (see Figure 2.5).
Economic analysis: theoretical foundations

In this chapter we review economic theory to find concepts which can serve as a theoretical foundation on which COMET can be built. Yet, discussing all schools of economic thought is impossible in the confines of this book. We therefore limit the analysis and discussion to the concepts of cost-benefit analysis (CBA) as developed in welfare economics and the concepts developed in transaction cost economics (TCE). For the analysis of both theories we use the following step-wise approach. In the first step a particular concept is explained. In the next step we investigate its use for telematics investments and illustrate this with examples. Then we review the implications for the development of COMET. Next, the application of the concepts for practical use in decision-making on telematics and possible complications are discussed.

The chapter is structured as follows. In section 3.1 we review the CBA concepts from welfare economics. In section 3.2 we review the TCE concepts and section 3.3 ends this chapter with conclusions.

3.1 Use of welfare economics CBA-concepts

In this section we review concepts of cost-benefit analysis (CBA) as applied by the World Bank (see a.o. Squire and Van der Tak, 1975; Baum and Tolbert, 1985; Squire, 1989). While welfare economics is a macroeconomic approach, we first translate the welfare economics-concept into a business economics-concept before the use of the concepts for telematics investments is analysed. We start this section with a general introduction of welfare economics after which the concepts are introduced.
The foundations of CBA lie in welfare economics. CBA was initially focused upon valuing large infrastructure projects and other public sector projects of which the benefits were unclear. In welfare economics three analyses are performed: financial analysis, economic analysis and social analysis, as represented in Figure 3.1 (Pearce and Nash, 1981; Pearce, 1983). Sometimes, the latter two are combined (Squire, 1989). CBA is a technique intended to improve the quality of public policy decisions, using money as a metric of the aggregate change in individual well being resulting from a policy decision.

Figure 3.1 Cost-benefit analysis

The purpose of CBA is to detect which benefits in what form will accrue (to whomsoever). Pearce (1983) sees CBA as a procedure for

- measuring the gains and losses to individuals, using money as the measuring rod of these gains and losses,
- aggregating the money valuations and expressing them as a net social gains or losses.

In welfare economics, the financial analysis is directed at deriving the costs and benefits which are directly related to the project under consideration. It basically reflects private objectives and normally includes a profitability analysis as well as a financial plan indicating from which sources the project costs are being financed (Kuyvenhoven and Mennes, 1985). The economic analysis is performed to investigate whether a project is attractive and desirable from a national point of view. It analyses whether resource allocation in the projects is efficient relative to their alternative uses.

Compared to the financial analysis, the economic analysis applies two major adjustments (Kuyvenhoven and Mennes, 1985). The first takes account of the fact that actual revenues and expenditures as specified in the financial analysis do not have to correspond with those for society as a whole (see 3.1.3). The second adjustment concerns the use of shadow prices instead of market prices (see 3.1.6). In a social analysis, considerations of allocative efficiency, growth and distribution of income are simultaneously taken into account at the level of project planning (from a society’s point of view). A social rate of return is determined which is an indicator for the impact of the investment on the income distribution (for example, between social classes or between regions).

According to Kuyvenhoven and Mennes (1985), each decision to commit funds to a project should in principle be subjected to the logic of CBA. CBA ensures that all the relevant factors which contribute to a
project's net benefits are systematically taken into account, whether they relate to an individual, a firm, a social group, the public sector or the country as a whole. From that perspective, telematics investments should also be analysed by a CBA. In essence, CBA is a life cycle analysis of both the costs and benefits associated with a project. A traditional cost-benefit analysis typically consists of five steps (Whiting et al. 1996):
1. Defining the scope of the project.
2. Evaluating costs and benefits.
3. Defining the life of the project.
4. Discounting the values.
5. Sensitivity analysis.
If we relate this to the decision model presented in the previous chapter we see that these steps support the objective setting and assessment stage of the model. The results of step four give support to the choice stage. No explicit support is given to the alternatives generation stage.

### 3.1.1 Objective in welfare economics

The objectives of a project determine how the project's costs and benefits are defined: anything that affects the objectives adversely is a cost while anything that promotes them is a benefit. In welfare economics the objective is to maximise utility or welfare. In this theory, a benefit is any gain to any individual or party in the group under consideration. That gain can either be financial or non-financial. In economic terms, the benefits reflect some welfare or utility gain. In the same way, costs are seen as anything that imparts a loss of welfare or utility.

**Business economics**

In business economics, CBA takes maximisation of shareholder value or profit maximisation as the objective for individuals and private business firms. From a private point of view, the actual receipts and expenditures expressed in present or future market prices are the relevant benefits and costs (Kuyvenhoven and Mennen, 1985). One can question whether profit or shareholder value maximisation is the sole objective for organisations. Often, they will also state other objectives in their mission and strategy. It is possible that profit or shareholder value maximisation is the ultimate goal of the organisation. Because that goal can be reached in many ways, organisations will usually have adjacent or sub-goals to the maximisation objective.

**Telematics investments**

Telematics investments usually do not directly contribute to profit or shareholder value maximisation. The contribution to profit maximisation
must be sought in the differential improvement of contribution of the supported process to the objective.

A problem which occurs in relating the costs and benefits of the telematics investment to the profit maximisation objective is the indirect relation between the investment and the objective. If, for example, an organisation wants to use certain telematics applications, it will first have to invest in infrastructure. There will be no direct relation between the infrastructure and the profit maximisation objective.

Next to that, telematics investments often are part of a larger package of investments (a business proposal, see chapter 1). This makes it difficult to track down all costs and benefits generated by the investment in telematics. For example, if an organisation wants to alter its invoicing process, it can invest in a telematics application such as EDI. Yet, the process itself will most likely also change, which makes adaptation of the organisation necessary.

**Implications for COMET**

COMET should support the clarification of the contribution of the telematics investment to the objectives. It should therefore make clear the relation between the objectives, between the objectives and the business processes and between the business processes and the telematics investments (see Figure 3.2). This makes a causal line of reasoning possible: if we invest in an EDI application to support information exchange of our invoicing process then the process will be more efficient and less error-prone thus generating lower costs and higher benefits, which contributes to our profit maximisation objective (Figure 3.3). Of course, this example is highly simplified and in practice a myriad of relations between objectives, processes and investments will exist. However, a clear understanding of the relation will improve the insight into the contribution of the investment to the objective.

![Figure 3.2 Causal relation between telematics and the objective](image)

![Figure 3.3 Causal relation between an EDI-investment and return on investment](image)

The second issue to be addressed by COMET is the interrelationship between investments in telematics and other business investments. The latter can be investments in other support equipment, but also investments in organisational change and adaptation of processes to new situations. Because it is difficult to appoint costs and benefits to the individual
investments, COMET should treat the combined set of investments as a single alternative or business case. If the investments are really inextricable, we should question the use of tracking the costs and benefits down to the individual parts of the alternative. Decision-makers should weigh the added value of the extra information against the assessment effort.

**Practical use**

Profit or shareholder value maximisation is not suitable to serve as objective for investing in telematics, while it disregards many effects which decision-makers should take into account. It can be an ultimate objective which should be made concrete by sub-objectives to which the business processes need to comply.

### 3.1.2 Cash flow analysis

The financial analysis in welfare economics and business economics is broadly the same, only the stakeholders are different. In both analyses, cash flow accounting is applied. This is the systematic recording at market prices of all forecast expenditure on goods and services, interest payments, taxes and dividends (cash outflows) and of all forecast receipts from sales, net-borrowing and equity capital (cash inflows) from a project throughout its economic life-cycle (Kuyvenhoven and Mennes, 1985).

Cash inflows usually consist of equity capital, borrowing (loans, suppliers' credit, current liabilities), current sales or revenues net of indirect taxes and subsidies. The cash outflows consist of investment in fixed and working capital, operating costs (payments for material inputs, labour, administration, sales, distribution), repayments, direct taxes (corporate tax, income tax) and dividends.

An activity in cash flow analysis is the estimation of the revenues and expenses. This often requires much effort because it is difficult. Difficulties in estimating the revenues at the macro-level range from problems in determining what the additional outputs produced by the project are worth to the economy to problems in assessing what the outputs in fact are. The usual practice is to derive a measure of the benefits from the revenues received from the consumers, which can be estimated with some reliability. Walshe and Daffern (1990) point at some problems which can occur when estimating the expenses of a project.

1. It is difficult to estimate when costs will be incurred during the economic life cycle of a project.
2. It is difficult to define the boundaries outside which costs will be ignored.
3. Economies of scale (available internally or to external suppliers) can hardly be projected.

4. Project appraisals often do not anticipate real terms increases in recurrent costs. Decision-makers often are confronted with costs that have been incurred on a project prior to the time of the analysis and that therefore cannot be avoided. These are sunk costs. They should be excluded from the cost of the project for the purpose of deciding whether to proceed with it. Bygones are bygones and only costs that are yet to be incurred matter in this regard.

**Business economics and telematics investments**

Cash flow analysis is commonly used in business economics. The statements above are also valid at this level. Here, private organisations are stakeholders. The approach can (and should) be applied to telematics investments as well. The problems of estimating the revenues and expenses are not different in business economics. For telematics investments some remarks are in place. While estimation of the timing of costs is difficult, determining the telematics life cycle itself is also a problem. The fourth estimation problem mentioned by Walshe and Daffern is particularly relevant for telematics investments in inter-organisational settings. Decision-makers cannot longer use the organisational border as a boundary, because (intended) effects will occur in the partner organisations.

Sunk costs also exist for telematics investments, especially in situations in which legacy systems are present. In analysing the cash flows of telematics, the sunk costs must not be taken into account.

**Implications for COMET**

The expenses and revenues generated during the life cycle of the telematics alternatives should be addressed by a cash flow analysis. This analysis should be a part of the assessment module of COMET. In a separate step in the assessment module of COMET special attention is paid to estimating the life cycle of the telematics investment. The scope of analysis will be broadened to take account of other than direct effects. Furthermore, secondary effects will also be treated, as stated in 3.1.3.

**Practical use**

Cash flow analysis is a common approach for assessing the effects of investments. As such it can be a useful component of COMET. It is well known by decision-makers and thus is expected to be used. Moreover, by using a common approach, which cash flow analysis is, comparison of different investments becomes easy and does not treat a telematics investment as a wholly unique type of investment.
3.1.3 Other than direct effects

Direct effects give rise to receipts and expenditures within the confines of the project and are relevant to financial analysis. In welfare economics, next to the direct effects, external effects, linkage or indirect production effects, price effects and multiplier or secondary effects are recognised. These effects all imply a benefit or a resource cost which is not reflected in the financial receipt or expenditures of the project.

External effects are defined as those project effects which constitute a benefit or cost to society, but are not reflected in the project’s financial receipts or expenditures. In other words, an action of an actor within the project causes a welfare loss (or gain) to another (group of) actors in society, which is not compensated.

Linkage effects are effects on other industries. Forward linkages refer to the effects on industries that are users of the project’s output, backward linkages refer to the effects on industries which supply the project’s inputs.

If the increased output of a project alone (for example, steel) or the increased project demand for an input alone (for example, electricity) leads to a substantial price reduction as a result of economies of scale, such a price effect should be taken into account as an additional benefit to the project. In this situation, with, and with the project alone, gains accrue to the rest of the economy which are not reflected in the direct project benefits (Kuyvenhoven and Mennes, 1985).

Multiplier effects occur when income (wages, salaries and profits) generated by an investment is spent on goods and services that can be readily produced because of general over-capacity.

Business economics

Since the above mentioned effects do not impose costs or confer benefits within the confines of a project itself they are therefore generally not included in the project’s financial accounts in business economics.

Telematics investments

The effects of a telematics investment often are beyond the intended objective and scope (Symons, 1994). Next to that, telematics investments usually occur in an inter-organisational setting. This implies that it is not enough for the decision-maker to look at the consequences of the investment for its own organisation. As such, the effects resemble the above mentioned linkage affects. Although external effects will not be taken into account, a scope extension from organisation to the chain or network may internalise effects which at the organisation level would not have been taken into account. The price effects as in the above given sense and the multiplier effects are not relevant. However, price effects can occur as a consequence.
of telematics investments. For example, these effects may occur when shifts in markets from traditional towards electronic ones take place. Electronic markets can be more efficient than traditional ones, which may put pressure on prices of goods and services.

In many studies on the effects of telematics investments, emphasis is put on qualitative effects which occur besides the quantifiable effects. This seems to be underdeveloped in the business economics CBA. In theory it simply stated that CBA ensures that all the relevant factors which contribute to a project's net benefits are systematically taken into account.

**Implications for COMET**

Next to the direct effects, external effects and the linkage effects, or in other words, the effects to other parties in the environment should be addressed as well. When possible, they should be internalised in the decision. As such, **COMET** should support decision-makers in finding all effects of the proposed investment. Two approaches are possible.

First, we suggest to analyse the investment from a business process perspective next to an organisations perspective, see Figure 3.4. By applying a business process perspective, the decision-makers obtain a clear picture of which (shared) processes will be influenced by the investment.

![Figure 3.4](image)

Organisations view (top) vs. business processes view (bottom)

Second, we suggest to pay explicit attention to the effects occurring in other processes than those which are intended to be supported by the investment. The occurring effects are the **secondary effects**. Our definition is the following:

*Secondary effects are effects outside the unit(s) in which the investment is to be carried out.*

The secondary effects can be treated in the same way as the direct effects, although some steps in the decision process, like estimation, will demand more effort.

Furthermore, **COMET** should offer possibilities to find and assess qualitative effects, most likely in addition to the financial CBA.
**Practical use**
For decision-makers it will become necessary to broaden their view on the consequences of the investment across the organisational border. This especially holds for inter-organisational investments. Adoption of a business process view instead of an organisations view will also be necessary.

3.1.4 **Cost recovery**

The main reason to undertake projects is the expectation that the results improve the current situation. In other words, the projects' discounted revenues will at least equal the discounted expenditures, but are preferably larger (i.e. net present value (NPV) ≥ 0). The World Bank suggests that from a welfare economics perspective a sound cost recovery policy should contain three necessary ingredients (Baum and Tolbert, 1985):
- *Economic efficiency*, ensuring that scarce (national) resources are used efficiently;
- *Income distribution*, recovering project costs in a way that promotes a more equitable distribution in society (what 'equitable income distribution' should be is a matter of debate). Income distribution is separately dealt with in 3.1.5;
- *Revenue generation*, enabling the government to capture part or all of the increased net benefits for funding future investments in the same sector or elsewhere.

**Business economics**

Economic efficiency and revenue-generation are relevant at the business level as well. For private enterprises, the return of the project should at least equal what they could earn at the margin in alternative investments, after allowance is made for differences in risk.

**Telematics investments**

The issues of efficient use of resources and generation of revenues should also be addressed for telematics investments. Moreover, efficiency improvement, i.e. making better use of scarce resources is often a trigger for investing in telematics.

**Implications for COMET**

A minimal requirement for alternatives is that NPV is ≥ 0. This will become clear in assessing the alternatives. This requirement has no further implications for COMET.
Practical use
In business economics, an alternative’s NPV should be ≥ 0 for an organisation to invest in it. This is not different for telematics investments. Efficiency issues and revenue generation are important in this situation and will be commonly used. We do not see any practical problems related to this issue.

3.1.5 Distribution of income

In welfare economics, next to the direct project revenues, often the impact of the investment on the income distribution of different groups in society is determined. Therefore, weights to consumption gains accruing to beneficiaries at different income levels may be assigned. This is a matter of judgement. Another approach is a redistribution of income separate from the project. The World Bank demands for every project a social analysis and has set rules to assure that this analysis is used consistently for all projects in which it can be applied meaningfully. By these rules, the World Bank tries to prevent that the analysis is used just as a device to get approval for projects that are otherwise unacceptable because of low returns (Baum and Tolbert, 1985).

Business economics

The impact of an investment on income distribution from a society’s point of view is not taken into account in business economics, because other objectives are relevant here (see 3.1.1).

Telematics investments

Organisations frequently have problems in investing in inter-organisational telematics investments, not because of the investment itself, but due to the fact that no proper agreement can be made on the division of the costs and benefits. The discussion on the allocation of costs and benefits among each other can be started by making a reference to income distribution, that is, how the expected costs and benefits will be divided amongst the parties involved when the investment is implemented. If a skewed division occurs, decision-makers may develop alternative implementation strategies, leading to different costs and benefits divisions.

Implications for COMET

If we make a reference to income distribution of different stakeholders in decision-making, it will probably be used in negotiation between decision-makers (of different organisations) on the division of costs and benefits, which can occur in every decision stage. In that case, COMET should make use of, or recognise this concept in each module.
Practical use
If we see income distribution as the way costs and benefits which result from an inter-organisational telematics investment are divided amongst partners, this concept can be applied in practice. Division of costs and benefits will most likely be an important (negotiation) aspect during the decision process.

3.1.6 Opportunity costs and shadow prices
Opportunity cost is the key cost concept in public sector project appraisal. Committing a resource to a specific use necessarily implies missing other options. The opportunity cost of a resource used in a particular way is defined as the value it could command if it were used for the best available alternative (cf. Walshe and Daffern, 1990). In economic terms, a cost is always a forgone benefit, which is an opportunity cost.

The opportunity cost may be reflected by market prices. Yet, in the appraisal of public sector projects, CBA uses some strict assumptions about the existing market prices to be used for reflecting the true value of the inputs and outputs (the market does not have involuntary employment, imperfect competition, large and indivisible projects, external effects and other market distortions). In reality, these conditions are often not met. The market prices are therefore usually replaced by shadow prices. Shadow prices measure the value of a commodity or a service from the viewpoint of society. They should better reflect the social value of the outputs and inputs of the project concerned. In principle, shadow prices exist for all inputs and outputs, and CBA often uses this term for prices which are imputed as opposed to being taken directly from market transactions. This might be the case because no proper market price exists or because the market price is considered to be inappropriate, because of the above given reasons (Pearce and Nash, 1981).

Business Economics
In business economics, private profitability measures reflect commercial objectives and are therefore invariably based on market prices. Therefore, the opportunity cost concept is not used. No use is made of shadow pricing either. Organisations take the market price of goods and services and expected cash flows as inputs for CBA. This also applies to telematics investments.

Telematics investments and COMET
For telematics investments by private companies, shadow pricing is not relevant and will therefore not be used by COMET. The existing market price
or expected future market prices will be used in COMET when calculating cash flows. The opportunity cost concept is relevant to analyse the consequences of other actions than investing. In other words, the concept can be of help to answer questions like: what will happen if we do not invest; what future options do we miss; what else can we achieve with these resources, etc. The opportunity cost may give an indication of the ‘vanishing status quo’ of the organisations if no investments are undertaken (Clemons, 1996). See also the next section and chapter 7.

### 3.1.7 Differential approach

Comparing the situation *with* and *without* the project constitutes the basic method of measuring the additional benefits that can be attributed to the project. Proper specification of the with and without situations, including an understanding of the relationships between the project inputs and outputs and their phasing over time, is a prerequisite to any cost-benefit analysis, financial or economic. Although tempting and easier, a before-project and after-project analysis is incorrect, while it does not recognise that when the project is not implemented there will still be changes in the initial situation. The ‘without’ situation refers to a prolongation of the current situation into a situation that can conceivably expected to apply in the absence of the project.

**Business economics and telematics investments**

The differential approach is not only appropriate from a welfare economics perspective, but is also common in business economics. In capital budgeting, all factors which change due to the investment decision should be taken into account. For telematics investments the ‘with’ and ‘without’ approach also applies.

**Implications for COMET**

For COMET this implies that the alternatives first must be assessed on their individual merits. Then, they must be confronted with each other and with a ‘base case’ which represents a prolongation of the initial situation.

**Practical use**

If both benefits and costs vary among alternatives, then each alternative, with its costs and benefits streams, must be assessed separately, so that the alternatives with the highest net benefits can be selected. The description of the situation without the project, i.e. the base case is partly a matter of judgement and can give problems in determining which effects would be caused by the alternative and which effects would have occurred anyhow.
3.1.8 Valuation

For valuing benefits of projects (that is, applying financial values to project effects), Walshe and Daffern (1990) offer some methods. They recognise five methods which either determine the consumer willingness to pay or producer costs incurred.

1. Market price and quantity information - the difference between the current situation and the situation in which the project is implemented is determined by the differences in prices and quantities consumed.
2. Cost savings - the results of the project are measured as savings on either capital expenditure or recurrent costs.
3. Transaction cost method - if the prices of products are not clear, consumer willingness to pay may be determined as a minimum value by the costs of the transactions to acquire the goods (like travelling).
4. Related market pricing methods/hedonic-pricing methods - of some products it cannot be directly observed what the customer is willing to pay. It might be reflected in related products.
5. Stated preference methods/contingent valuation methods (the interview method) - in this situation, a consumer states a willingness to pay for a certain good.

Business Economics and telematics investments

From a theoretical point of view, all of the above mentioned methods can be applied in business economics as well.

As we noted in chapter 1, assessing costs and benefits for telematics investments is difficult. One of the main reasons which causes this difficulty is the question how to value the non-financial costs and benefits. Not all costs and benefits can be properly expressed in financial terms or can be quantified, which makes valuation difficult. COMET should contain possibilities to assess these benefits.

The five methods mentioned above are actually intended to find proper price levels and they may be of use for valuing non-financial effects of telematics investments. The first two approaches are probably the most easiest to apply. We should bear in mind, however, that not all telematics induced benefits can be derived from pricing and cost savings. This will only apply in a number of cases.

The transaction cost approach may be useful in the development of inter-organisational systems. It can be used to find out how much effort (i.e. money) they are willing to put into developing inter-organisational systems.

The related market pricing method can be used in the form of a benchmark. If decision-makers can find existing investment projects with the same characteristics as telematics investment projects, they obtain
insight into which effects can occur and what size these effects have. For instance, a decision-maker may try to benchmark the telematics investment with an investment in product development.

The contingent valuation method can be used to (quantitatively) value intangible effects of telematics investments. For example, an increased use of just in time (JIT) deliveries may lead to increases in stress for the employees and congestion at the roads. Both can be valued by using the contingent valuation method.

Next to this use, an organisation may use the willingness-to-pay approach to find out whether its customers are prepared to pay for new services which can be derived from the telematics investment.

**Implications for COMET**

Determining the value of a telematics investment cannot easily be based on market prices for products the organisations sell. This is due to the fact that many telematics investments are intended to support processes. Yet, assessment may render as a result that an expected increase or the maintenance of market share will be result of the particular investment.

In COMET the valuation should be based on all effects of the investment (see chapter 1). This means that all these effects should be valued. Assuming that a mixture of the five methods renders a complete set of valued effects, this mixture of methods may be of use in the methodology.

**Practical use**

The individual methods are often used in market research. As given, a mixture of the methods will give a good overview of all valued effects.

### 3.1.9 Assessment methods and discounting the future

In welfare economics, measures of project profitability are the net present value (NPV), the internal rate of return (IRR) and the benefit-cost ratio.

The CBA approach also takes account of time preferences. This implies that decision-makers usually value current costs and benefits higher than benefits gained and costs incurred in the future. The future effects are valued by discounting them back to current figures. In order to do so, a discount rate must be determined. For operational purposes, the discount rate is usually set at a fixed percentage, including a risk premium (in real terms, i.e. net of inflation). Prevailing interest rates tend to have a number of components: the real time value of money, the inflation rate and risk. Note that when an interest rate in real terms is used, also cash flows in real terms have to be used.

It is desirable that CBA takes into consideration the range of possible variations in the values of the basic elements and that the extent of the
Sensitivity analysis and risk analysis are used in business economics. Net present value, internal rate of return and the benefit-cost ratio are also common in business economics. Discounting is also common practice. Often, the same approach as in welfare economics is used and a fixed discount rate is chosen.

Both sensitivity analysis and risk analysis can and are used in business economics.

**Telematics investments**

For investments in telematics NPV and the benefit-cost ratio are useful, but they should be used with care. We are aware of the importance of intangible benefits and that costs will vary from project to project, so that any comparison of projects on the basis of an (economic) index of investment worth, such as NPV, has to be made with considerable care. While many non-financial effects occur they should either be given a financial value, or the non-financial effects have to be taken into account by using additional assessment methods.

Because investing in telematics involves much uncertainty, sensitivity and risk analyses can be of great use.

**Implications for COMET**

In COMET the NPV will be used (reasons for using NPV are given in chapter 5). The financial valuation methods alone are not sufficient for a clear picture of the value of the alternatives, they will be expanded with methods which can offer insight into the non-financial and non-quantifiable effects of the investment. The assessment module of COMET will contain more existing methods in order to make analyses on different effects (financial, quantitative or qualitative) possible.

Sensitivity and risk analysis should form a part of the assessment module in COMET.
**Practical use**

Financial discounting is common practice and the NPV method is straightforward in use. In practice, decision-makers tend to apply a risk premium to the discount rate. We should be careful that the discount rate for the NPV is not augmented too much with a fixed risk premium. This is because in telematics investments often costs occur early in the life cycle and benefits later, or even by additional investments in applications, as is the case for infrastructure (see chapter 1).

Another issue is the increasing risk assumption: applying a risk premium to the discount rate lowers the future cash inflows. However, besides lowering inflows, future expenses are lowered as well (they are brought to 0), perhaps even that much that alternatives mostly are accepted.

### 3.1.10 Infrastructure projects

Estimation of benefits for infrastructure projects, such as highways, is very difficult in welfare economics (in fact, infrastructure projects were the trigger for the development of welfare economics). For most infrastructure projects, tariff-based revenues are not available as measures of the economic benefits of the (transport) services provided by the project. Another approach is the estimation of the so-called avoided costs, such as expected increases in vehicle operation costs and road maintenance costs if the project does not go forward.

For many social infrastructure projects (education, health) no meaningful measurement of the monetary benefits exists, and a cost-effectiveness analysis is performed, focusing on providing service levels, determined by macro-economic and other considerations, in the most cost-effective manner. Even this may not be straightforward because the quantity or the quality of the outputs (or service levels) may not be the same for different input packages.

**Business economics and telematics investments**

The problem of estimating and valuing infrastructure benefits is actual in business economics as well and as such also applies to the estimation and valuation of telematics infrastructure. Yet, a cost-effectiveness analysis for telematics infrastructure is not appropriate because it focuses too much at the cost-side of the investment. This bypasses all benefits, both qualitative and quantitative. Besides, new services which may become possible by the investment are not accounted for.

**Implications for COMET**

The avoided-cost concept does not represent the merits of the alternative at hand, but the costs of the other alternatives. In COMET, first the alternatives
need to be assessed on their own merits and in a second step a comparison can be made. Then it becomes clear which alternative has highest cash inflows and/or lowest expenses. For comparison with prolonging the initial situation, we will use a ‘base case’ (see 3.1.7).

An analysis of both the costs and benefits side remains necessary and forms the basis of the assessment module of COMET. Thus, within the assessment module of COMET full CBA is presented and not the cost-effectiveness analysis, while the latter does not capture any benefits at all. For the input of future alternatives which become possible through the alternative at hand to the CBA of the alternative at hand we will investigate the possibilities of option pricing (see chapter 5).

**Practical use**
Valuing infrastructure projects is seen as a difficult task in practice. It is nevertheless necessary and by providing a sound CBA insight into the effects is improved. It is therefore necessary that the decision-makers take the time to perform full CBA.

### 3.1.11 Concluding remarks

In this section we did not discuss every concept which stems from welfare economics-CBA. Concepts which we did not address are:

- **Consumer surplus.** This is the difference between what consumers are prepared to pay for a product or a service and what they actually pay.
- **Border prices.** These are world market prices which can be used in shadow pricing (which is not relevant for telematics investments).
- **Transfer payments.** These are payments from one group in society to another. We can think of subsidies and taxes. In welfare economics they should be treated differently in the financial and economic analysis. For telematics investments they are incorporated in the cash flow analysis.

### 3.2 Use of transaction cost economics-concepts

In this section we review concepts of transaction cost economics (TCE). We start this section with a general introduction of TCE after which the concepts are introduced.

Where the traditional theory of the firm sees the organisation as a production function, TCE sees the organisation as a governance structure (Williamson, 1998). Instead of focusing upon the way production can be optimised, TCE focuses upon the way relations between entities are managed and asks the question why organisations do exist. TCE is not an
entirely new theory, but is partly complementary and partly rival to other perspectives on theory of the firm and market organisation. TCE focuses on aligning governance structures (markets, hybrids, firms, and governmental agencies) with transactions. The theory is grounded in New Institutional Economics, which tries to explain institutional environments and the nature of governance structures. Structures in the institutional environment are determined by politics (Williamson, 1998) and provide the framework in which economic activity is organised.

TCE sees how adaptation should take place as the central problem of economic organisation. Adaptation refers to either responses of individual parties to market opportunities or adaptations through changes in administration within the organisation.

### 3.2.1 The problem studied

TCE studies the existence of governance structures: why do markets and firms exist, why are there hybrids, regulation, non-profits and public organisations? TCE focuses on the relation between the specifics of a transaction and the related mode of governance. A central concept in TCE is governance. A definition is the following:

**Definition 3.2**

*Governance is the means by which order is accomplished in a relation in which potential conflict threatens to undo or upset opportunities to realise mutual gains.*

This rather abstract definition implies that parties that co-operate use a mechanism (for example a contract) to realise the goals they have agreed upon and to prevent problems which may be caused by opportunism. The definition relates to situations in which various stakeholders with different interests are involved in a decision process. Economies have two basic governance mechanisms for co-ordinating the flow of products or services through the adjacent steps in the value-added chain: markets and hierarchies (Coase, 1937, Williamson, 1975).

- **Markets** co-ordinate the flow through supply and demand forces and external transactions between different individuals and firms. The market forces determine the design, price, quantity and target delivery schedule for a given product that will serve as an input to another process. The buyer of the product compares its many possible sources and makes a choice based on the best combination of these attributes.

- **Hierarchies** co-ordinate the flow of products through adjacent steps by controlling and directing it at a higher level in the managerial hierarchy. Managerial decisions determine the design, price (if relevant), quantity and delivery schedules at which the products from one step to another are procured for the next step. Buyers do not select a supplier from a
group of potential ones, they simply work with a single predetermined one.

The differences between each form of governance are in TCE emphasised by the fact that a distinct form of contract law supports each of them. The implicit law of hierarchy is that of self-control. Given the description given above, the main differences between markets and firms are (Williamson, 1998):

- **Incentive intensity**: high-powered incentives at markets versus low-powered incentives in firms.
- **Administrative controls**: firms have a wider range of procedures and administrative rules.
- **Adaptation**: in response to changes in relative prices, markets have the advantage in effecting autonomous adaptation, whereas firms have advantage when more co-operative adaptations are needed.
- **Contract law**: the contract law at markets is legalistic and relies on court ordering whereas the organisation replaces court ordering by private ordering and settles disputes by fiat (which makes the firm its own court of ultimate appeal).

**Telematics investments**

How does TCE relate to telematics investments? Telematics investments cross-organisational boundaries may affect existing governance structures: firms may be forced to co-operate in the investment in order to reap all benefits. TCE can be used to explain the consequences of changing governance structures. Next to that, telematics may introduce new forms of governance, like electronic markets, virtual organisations and electronic hierarchies (Malone et al. 1987). Malone et al. introduced the electronic market hypothesis, suggesting that for efficiency reasons a shift from physical to electronic markets will take place and a shift from hierarchies to markets take place. Currently, telematics facilitates new forms of electronic co-operation and trade, for instance through the Internet. This leads to new markets for organisations, evolving new organisations and a major shift in the competitive arena.

**Implications for COMET**

The concept of governance may be used in COMET to analyse the consequences of telematics investments in terms of changing governance structures. As such, it can provide decision-makers with more insight into the consequences of the investment for the relation between the firm (and process) and its environment.
Practical use
It is unclear whether decision-makers apply the governance-concept in practice to determine what consequences a certain investment to the governance structure will have and whether a shift towards a different form of co-ordination takes place. It may be useful, though, in explaining the relations with different stakeholders.

3.2.2 The human actor

The human actors in TCE are assumed to be bounded rational. Their intention is to be rational, but given their cognitive abilities, they are only rational to a limited extent. As a consequence, all complex contracts are seen in TCE as unavoidably incomplete (Williamson, 1998). This, however, does not imply that decision-makers are short sighted. In TCE, decision-makers look ahead, perceive hazards and take these into account in their decisions.

Telematics investments
The fact that the human actor is assumed to bounded rational has no consequences for telematics investments in particular. Bounded rationality may imply that people have difficulties in coping with situations which require a large and complex amount of information. This latter situation will often be the case for inter-organisational telematics investments.

Implications for COMET
In chapter 2 we argued that we would use the concept of bounded rationality while this closely resembles practice. This is in alignment with the perspective on the human actor in TCE.

Group decision support systems (GDSS), like cognitive mapping, are supposed to stretch the cognitive limits of decision-makers. If we consider COMET to be a support mechanism for group decision-making (which will normally the case for complex telematics investments), it should also be able to stretch cognitive limits of its users. COMET should help its users by lowering complexity of decision situations, thus making decisions based on better analysis possible. Forcing them to think of the future possibilities and consequences of current alternatives should support future orientation of decision-makers.

Practical use
As given above, the concept of the bounded rational man closely resembles practice and it is therefore expected that using this concept in COMET is appropriate.
Next to bounded rationality, human actors handle according to a degree of self-interest (Williamson, 1998). In TCE this self-interest is seen as opportunism of the human actor, which must be neutralised by additional contractual agreements. Opportunism is seen as a basic foundation for the existence of organisations: in the absence of opportunism their is no contractual reason to replace market by hierarchy, because people are honest and can trust one another on their word. A reduction of ex post hazards of opportunism through the ex ante choice of a governance structure is central to TCE. Opportunism should be dealt with by giving and receiving credible commitments. Thus, it is expected that an order is realised, potential conflict is mitigated and mutual gains can result.

**Telematics investments**

Since telematics investments often cross boundaries of organisations, stakeholders in the decision process will most likely pursue different objectives with the investment. This does in itself not have to be a problem, but a shared interest in the investment is at least convenient. The use of a contract can be a means of aligning the objectives or describing the mutual gains to be attained.

**Implications for COMET**

It is not likely that a decision support method will be able to prevent opportunism (the method or its results can almost always be altered to suit the specific purposes of its user). However, by clearly structuring the decision process and giving possibilities to perform steps in the decision process either jointly or separately, COMET may limit opportunism and create mutual commitment. If COMET can be presented as a clear ‘tool’, it can be used as a means of communication between stakeholders, for example by using the tool as a means to transfer results from one group to another. Thus, it can support consensus creation in a group.

As given in chapter 2, we will amend the bounded rationality concepts with concepts from the political model to cope with opportunism where necessary and possible.

**Practical use**

Opportunism is a reality in daily decision-making. Despite the fact that it may be possible to equip a method with mechanisms to prevent opportunism, it remains questionable whether this will be used in practice. Decision-makers probably do not want to be forced by a supporting method in taking certain steps.
3.2.3** Description of the organisation and its boundaries**

Contrary to the description of the organisation in terms of a production function as in neo-classical economics, TCE sees the organisation as a governance structure.

Theories of the firm should be able to explain the boundaries of an organisation. In TCE, the efficient organisational boundaries are not searched for in terms of technology (economies of scale and scope), but in terms of aligning different transactions with governance structures in a discriminating way (Williamson, 1998). The boundary of the organisation is the set of (value-adding) stages for which the make-or-buy (i.e. vertical integration) decision is resolved through replacing market by hierarchy. In the organisation so described, the ownership of value-adding stages is unified, investments and strategic decisions are co-ordinated by hierarchy and those disputes for which adjacent value added stages (i.e. different processes or organisations) are unable to reach agreement are decided by fiat.

**Telematics investments**

Recognition of the formal boundaries of the organisation is particular for decisions on border crossing telematics investments. It can be of help in determining responsibilities for the investment and in analysing the location of occurrence of the investment effects. This latter analysis can be of help in the negotiations on the division of costs and benefits.

**Implications for COMET**

In order to determine the impact of a telematics investment, all effects have to be taken into account. For many telematics investments, the scope of the organisation will be too limited to analyse all effects. As already indicated in section 3.1.3, COMET should adopt a business process view instead of an organisations view. After analysis of the effects, the organisations structure can be put over the processes structure as input for costs and benefits division.

**Practical use**

The governance structure as described will be recognised by the decision-makers and most likely determine their (negotiation) position in the decision process. For the analysis of the location of effects, the governance structure is of less relevance.

It is often assumed that large firms can do everything that a collection of small ones can, by replication and selective intervention. TCE provides arguments why this assumption does not hold (Williamson, 1998):
Internal organisation (the large firm) cannot replicate small firms (market procurement) in incentive intensity respects.

The agreement to always intervene but only for good cause (selective intervention) unenforceable (human actors are bounded rational and are therefore not capable of solely taking the right decisions).

The hypothetical advantages of combining replication with selective intervention cannot be realised without a trade-off between the benefits of added co-ordination/co-operation on the one hand and the costs of added bureaucracy on the other.

As against a hypothetical ideal, TCE advances the remediableness criterion, according to which an existing mode of organisation for which no superior feasible alternative can be described and implemented with expected net gains is presumed to be efficient (Williamson, 1998). If a proposed alternative is superior to an existing situation in a comparison, decision-makers should still further examine implementation obstacles (costs of migration from the existing situation to the new situation). If it is very difficult or costly to overcome existing conditions, then implementation with net gains may not be possible.

**Telematics investments**

The issue whether a large organisations can do everything a small group is capable of doing, is of no direct relevance for telematics investments. Yet, an assumption may be that large organisations are better equipped to introduce large-scale telematics investments which affect many stages in the production process. Reasons for this are that large organisations simply may have internalised many steps of the production process, they may have sufficient financial leverage to individually perform investments and they may be large enough to force their partners to be involved in the investment process.

**Implications for COMET**

COMET will not focus upon the pros and cons of organising transactions in a large single organisation or a group of smaller ones. It should, however provide means for a full analysis of alternatives, in which comparison with prolongation of the existing mode of organisations is possible and in which future possibilities are taken into account.

**Practical use**

The practical use of a large organisation over a group of smaller ones is already given under telematics investments: internalisation of production processes, financial leverage and (bargaining) power.
3.2.4 Unit of analysis

The unit of analysis in TCE is the transaction. This turns economics from analysis of choices towards analysis of contracts. For this analysis it is necessary that it is clear which attributes of transactions are of importance. Three aspects of commercial transactions which often have been studied in TCE are:
- The frequency with which transactions recur.
- The uncertainty to which they are subject.
- The specificity of the underlying assets.

Specificity of assets can take on the form of specific physical assets, specific human assets, information specificity, site specificity, etc. For each asset-specific situation a particular governance structure can be devised. There is not one, all-purpose, superior form of organisation. TCE uses the discriminating alignment hypothesis, in which transactions are aligned with governance structures, to realise efficient transactions (that is: minimising transaction costs). Transactions differ in their attributes and governance structures differ in their cost and competence. TCE aims at predicting efficient alignment between the two. If assets are specialised to the particular needs of parties, a premature termination of a transaction between them would sacrifice productive values. Usually, parties devise safeguards to prevent losses due to premature termination of transactions.

Parties can arrange safeguards in contracts, which is the usual arrangement of commitment between organisations. Parties can also opt to take transactions out of markets and organise them under unified ownership in which hierarchy is used to establish co-ordination. In this situations, unified ownership does not only mean single firms, it can also be co-makership, outsourcing, value-added partnerships, etc. see chapter 2. Because of the added bureaucratic costs involved in taking a transaction out of the market, internal organisation is often seen as the organisation form of last resort.

Telematics investments

From a transaction perspective, a telematics investment can be seen as a transaction between firms at a market or as a transaction in a hierarchy (the organisation). This perspective on an investment is not useful when an ex-ante analysis (assessment) has to be made in order to decide whether or not to invest. Yet, in some industries, like flower markets and financial markets a telematics investment may influence or alter asset specificity, in particular information specificity. This change in asset specificity may call for a different governance structure. Such far-fetching consequences should, of course, be taken into account when assessing the consequences of an investment.
Implications for COMET
The unit of analysis in COMET is the location (process, organisation, organisational network) where the telematics investment and its consequences apply. Applying the transaction concept on the telematics investment does not provide a complete basis for the analysis of effects of the investments. A use of the transaction concept as indicated in TCE is therefore not suitable to be used in COMET.

Practical use
The transaction perspective on investments can be of use to determine responsibilities and liabilities, as well as to find changes in a.o. asset specificity which may call for new governance structures.

The discriminating alignment hypothesis in TCE is a generic concept and does not engage the strategic concerns of individual firms. TCE views strategy formulation and positioning as second-order of importance. If TCE is to be more fully engaged in strategy, it should be made more specific to the situation for the organisations under consideration. The traditional transaction cost question of ‘what is the best generic mode to organise X’ should be replaced by ‘how should organisation A, given its strengths and weaknesses organise X’. Hence, the question explicitly focuses on a particular organisation and should take both competencies and disabilities of that organisation into account. While strategies are developed in relation to a market in which current and potential competition need to be taken into account, TCE suggests to comparatively assess strengths and weaknesses (i.e. benchmark the organisation with others).

Telematics investments
An investment, be it in telematics or something else, will always apply to a specific situation and cannot be analysed at a generic level. Thus, making the hypothesis concrete at the level of strategy formulation for the organisation under consideration, out of which investment plans can be derived, is very useful.

Implications for COMET
A general observation for COMET is that it should be as concrete as necessary for the decision process. The analysis should focus upon the proposed alternatives and their projected consequences.

Practical use
It is not likely that decision-makers explicitly or consciously use the discriminating alignment hypothesis for investments. In fact, they will implicitly use it. The observation that the hypothesis should apply to the
level of the unit under consideration applies to the decision process in general: it should be focused on the proposed alternatives.

### 3.3 Conclusions

Both welfare economics CBA theory and transaction cost theory contain useful concepts for COMET. Should we base COMET on one of the theories or can we start cherry picking and take the concepts from both theories which best serve our purposes? The answer to the latter question is an obvious 'no' in a situation of competing theories. Yet, they are not completely different, they offer insight in organisational behaviour from different perspectives, making it possible to combine (adjusted) concepts.

Is it necessary to use both theories as a basis for COMET? The purpose of the methodology is to support decisions on telematics investments. The theory should be able to cope with the issues relevant in the decision process. If we consider the issues related to telematics investments which we introduced in chapter 1 and the decision process model of chapter 2, the CBA concepts can all be applied without many necessary re-adjustments. For TCE this is different. The governance concept can be very useful in explaining relations between entities and in the division of costs and benefits. Yet, one of the central concepts of TCE, notably the concept of transaction cannot fully serve as a basis for investment decision-making. It may be useful in analysing the consequences of the investment for information specificity and the related governance structure. Still, this is only part of the analysis of investment effects. We therefore choose CBA as a basis for COMET.

**Using welfare economics CBA-concepts for COMET**

Using cost-benefit analysis in telematics assessment offers the following advantages:
- It forces a systematic approach towards the preparation of projects to ensure that all relevant factors which affect benefits and costs are taken into account. This implies that each project is treated similarly, which makes a comparison of projects possible.
- Financial analysis shows which consequences, both short- and long-term, can reasonably be expected when a project is actually implemented.
- The specification of all relevant expenditures and revenues during the economic life-cycle of a project in the financial analysis provides indications of the profitability of a project. This makes a meaningful comparison with alternatives (other projects or alternative specifications of the same project) possible.
The projection of financial cash flows which result from the expected pattern of revenues and expenditures, makes it possible to identify in advance any problems in the financing of a project. Systematically structuring the analysis of alternatives will improve insight into the effects of the possible telematics investments. For the development of our methodology two conclusions can be derived. First, a financial analysis is necessary to highlight the financial effects of the alternatives. Second, the systematic nature of the approach forces the decision-maker to take all relevant effects into account and improves the results of the assessment stage in the decision process. Hence, a financial component must be part of the assessment module of COMET and COMET should offer a systematic approach towards the decision process.

We should be aware, however, that a CBA alone can not be the basis for deciding whether or not to carry out a certain project. Other aspects of the projects should be assessed as well (if they are not directly or indirectly taken into account by CBA). Kuyvenhoven and Mennes (1985) mention also non-quantifiable aspects like technical, commercial, institutional, organisational and managerial aspects.

If investments are considered which cannot be directly appointed to a concrete and tangible end product, like an improved information system, CBA should be used with care. Either the effects of the investments should be translated into financial values or other assessment methods should be used in concurrence. In COMET we approach this issue by introducing several existing assessment methods within the assessment module.

Another issue is that of causality: it is difficult to determine whether and how certain effects of the alternative are the result of the given telematics investment or are being caused by other (external) events, or combinations of both (Klaassen and Sas, 1990). This issue is treated in COMET by taking into account the entire investment package and not single out the telematics investment. We argue that this is possible because the telematics investment will usually be a part of a larger business investment.

A problem which may occur in practice is the reliance of decision-makers on the results of CBA. Especially in those cases where major project effects cannot be measured in advance or quantified in costs and benefits, the outcome of a CBA based only on measurable effects is of limited value. It should therefore be interpreted with the greatest care (Kuyvenhoven and Mennes 1985).
Telematics investments in practice

In the past decade, many researchers have studied the practice of investment decision-making. Deitz (1997) summarised the results of nine studies performed by various researchers into the practice of IT investment decision-making. He derived from these studies the following aspects.

- The use of specific methods for investment analysis of IT appears to be very limited in practice.
- The financial perspective seems to be very important, given that financial criteria are most frequently used. However, the real influence on a choice for a certain alternative is questioned. Results of several studies even indicate that a thorough financial analysis of IT investments in practice hardly takes place (Farbey et al. 1992).
- Decision-making is a very complex process. If one wants to steer the decision process, aspects such as culture, organisational structure, personality of those involved and informal processes should be taken into account.
- In practice, decision-makers often are satisfied with the way in which the decision process is performed, while researchers seriously question the approaches used (Willcocks and Lester, 1994).
- At the moment there are hardly any results on the implementation and use of normative decision methods. Their usefulness for practice is therefore unclear.

To gain additional insight into decision-making practice and into the problems which decision-makers are confronted with, we study in this chapter how telematics investments are dealt with in practice by analysing several cases. To be able to perform the case analysis, we present an analysis framework in section 4.1. In section 4.2 we present six cases on telematics investments, which we have taken from “EDI in Europe - how it works in practice”, edited by Krcmar et al. (1995). That book describes 14 cases from different European countries in which different types of companies
successfully invested in EDI for communication with their partners. In section 4.3 we summarise the observations, combined with the observations of Bjørn Andersen and Krcmar (1995), who performed a cross-analysis on all cases from “EDI in Europe”. On the basis of these observations we derive conclusions, which are input to the requirements for COMET. We return to the conclusions in chapter 6.

4.1 Analysis framework

We will use the decision model which we introduced in chapter 2 to investigate the cases on the way in which decisions are being made in practice and the related problems which (may) occur. For each stage in the decision process, several aspects are important to investigate. The aspects studied in the respective cases are given in Table 4.1.

<table>
<thead>
<tr>
<th>Stage in Decision Process</th>
<th>Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective setting</td>
<td>1. by whom – which parties are involved</td>
</tr>
<tr>
<td></td>
<td>2. what trigger/why</td>
</tr>
<tr>
<td></td>
<td>3. support (which methods)</td>
</tr>
<tr>
<td></td>
<td>4. criteria and constraints – financial/non-financial, quantitative/qualitative, risk, constraints</td>
</tr>
<tr>
<td></td>
<td>5. what is to be achieved</td>
</tr>
<tr>
<td></td>
<td>6. how to achieve the objective</td>
</tr>
<tr>
<td>Alternatives generation</td>
<td>7. by whom</td>
</tr>
<tr>
<td></td>
<td>8. how</td>
</tr>
<tr>
<td></td>
<td>9. support (which methods)</td>
</tr>
<tr>
<td></td>
<td>10. constraints</td>
</tr>
<tr>
<td></td>
<td>11. (form of) result</td>
</tr>
<tr>
<td>Alternatives assessment</td>
<td>12. by whom</td>
</tr>
<tr>
<td></td>
<td>13. how - formal/informal – structured/unstructured – quantitative/qualitative</td>
</tr>
<tr>
<td></td>
<td>14. support (which methods)</td>
</tr>
<tr>
<td></td>
<td>15. reliability results</td>
</tr>
<tr>
<td>Choice</td>
<td>16. by whom</td>
</tr>
<tr>
<td></td>
<td>17. how</td>
</tr>
<tr>
<td></td>
<td>18. support</td>
</tr>
</tbody>
</table>

By using the aspects introduced in Table 4.1 we want to investigate the following.
1. By whom Which people/parties are involved in the objective setting stage?
2. What trigger/Why What is the reason for coming to an investment objective?
3. Support Do the parties make use of methods to
   - Scan problems/opportunities and/or
   - to generate clear-cut objectives and decision criteria
   - and/or to gather first information?
   If so, which methods?
4. Criteria and constraints Which criteria and constraints are explicitly mentioned as basis for the decision?
5. What Which objective is set, and is it of an operational or strategic nature?
6. How to achieve the objective What are the parties planning to do to achieve the objective?
7. By whom Which people/parties are involved in the alternatives generation stage.
8. How Do the involved parties follow some kind of (explicit) procedure to generate alternatives, and if so, what procedure is in use?
9. Support Do the parties use methods to generate alternatives; which methods?
10. Constraints Are there any explicit (costs, time) constraints set on the generation process?
11. (form of) result What are the results from this stage (a number of alternatives?) and how are they presented?
12. By whom Which people/parties are involved in the alternatives assessment stage.
13. How Do the parties follow a procedure to assess the alternatives (according to a fixed set of criteria, is it formal, structured, quantitative?), are they intuitively assessed or is another course of action in place?
14. Support Do the parties make use of supportive methods and/or tools. If so, which methods and what are their respective benefits and drawbacks?
15. Reliability results Is the assessment of alternatives reliable. In other words, do the actual results comply with the assessed results?
16. By whom Which people/parties are involved in making the choice?
17. How How do the parties make choices (by consensus, voting, ranking or in another manner)?
18. Support Is there support for the decision-maker (for example, the method used to assess the alternatives gives hints for choosing by ranking the alternatives)?
The above structure is also used to structure and present the cases in the following section.

4.2 Six explorative cases

The cases we have taken from “EDI in Europe” are described and analysed with the framework presented in section 4.1. First, we give a short description of each case and present the steps which were taken along the lines of our decision process model. For in-depth description of the cases we refer to “EDI in Europe”.

We realise that the cases are not presented to exactly fit our purposes and therefore that the use the cases for our research is limited in some areas:

- “EDI in Europe” explicitly presents successful EDI applications (Bjørn-Andersen and Krcmar, 1995) which may be used as examples for other organisations. Therefore, we cannot learn from experience with mistakes or failures.
- The cases are about EDI, whilst there are many other telematics applications.
- The organisations are all first movers or early adopters of EDI in their business.
- The organisations are all large size; no findings on small organisations are given.
- The cases focus on the introduction and use of EDI. This implies that the first decision cycles, in which the decision to use EDI as a solution for a certain problem is taken, is passed. It therefore remains unclear whether the use of EDI is seen as a single solution to meet the objectives (out of several generated alternatives) or that the use of EDI is one of the solutions chosen to fulfil the requirements set by the objectives (next to, for example, investments in production equipment).
- This indicates that a decision for a certain direction in which to find a solution has already been taken. For the stage generation of alternatives this means that alternatives are generated at the level of finding software, hardware, partners, etc.

4.2.1 Purchasing through EDI - the case of Technische Unie

In this case, described by Ribbers (1995), the introduction of EDI for the purchasing function at Technische Unie Nederland (TU) is analysed. TU was a wholesaler in electrotechnical and sanitary products supplying professional customers in the construction industry. TU was market leader with a strong competitive position. This position was maintained by means of availability
of a broad and deep assortment of articles and short reliable delivery times anywhere in the Netherlands. TUI aimed at an integral management of the logistics via TUI to the customers. TUI minimised its investments in inventory by sharing market information with suppliers and reducing throughput time to customer delivery. For this integral management concept, electronic links played a crucial role.

TUI saw the use of EDI as a next logical step in a long-term strategy towards integral logistic management and wanted to establish EDI links with suppliers with whom long-term business relations existed and who had an adequate information systems organisation. During the course of implementation, progress was slowing down due to technical reasons and organisational reasons. Technical reasons included a lack of connectivity of the suppliers’ information systems to the EDI application. Organisational problems occurred because TUI wanted to combine the EDI project with organisational changes, such as the industry-wide introduction of EAN bar codes and standard packing units. The suppliers understood the benefits of these changes, but questioned the necessity of combining them with the introduction of EDI.

### Objective setting

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Extensive existing experience with automation and a corporate policy to involve people in scanning emerging IT possibilities.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support</td>
<td>Keeping investment in inventory as low as possible</td>
</tr>
<tr>
<td>Criteria and constraints</td>
<td>Improving the delivery reliability of the suppliers</td>
</tr>
<tr>
<td></td>
<td>Possibility to enable quick and reliable delivery at low cost and the support of the corporate image</td>
</tr>
<tr>
<td>What</td>
<td>Generation of competitive advantage: IT was seen as an prerequisite for maintaining the market position. EDI could be a barrier against potential new entrants in the industry.</td>
</tr>
<tr>
<td>How</td>
<td>Through a series of bilateral EDI-projects. The first EDI partners would be sought among the most important suppliers. Philips was chosen because it was the most important supplier both in terms of purchasing volume and transaction volume. But also because there existed very good peer-to-peer contacts with the people from Philips’ IS department.</td>
</tr>
</tbody>
</table>

### Alternatives generation

| By whom | A steering committee consisting of Director of FAI, staff member of the IS and the organisation department. From Philips a staff member of the IS department and organisation department. A staff member from Holec and Draka, companies |
which were partners of TU.

Alternatives assessment

<table>
<thead>
<tr>
<th>How</th>
<th>Unclear.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Result</td>
<td>Unclear.</td>
</tr>
<tr>
<td>By whom</td>
<td>Steering committee.</td>
</tr>
<tr>
<td>How</td>
<td>The message standard was screened on the number of messages involved, potential quality improvement in terms of speed and error and potential efficiency improvement.</td>
</tr>
<tr>
<td>Support</td>
<td>No detailed cost-benefit analysis was made in the decision phase (yet, a CBA was done during the cause of the implementation).</td>
</tr>
<tr>
<td>Reliability</td>
<td>Unclear.</td>
</tr>
</tbody>
</table>

Choice

| By whom   | Steering committee. |
| How       | Unclear. |
| Support   | Unclear. |

4.2.2 A standardised success? - the case of Leroy-Merlin

Jelassi and Loebecke (1995) describe the case of Leroy-Merlin (LM), the second-largest distributor of do-it-yourself (DIY) products in France. It procured its supplies from about 4000 suppliers, of which 1000 are regular suppliers, and sold them to end customers through 59 company-owned stores. LM moved from a mass market to a multi-specialist market, meeting the expectations of a new generation of DIY customers.

The IT infrastructure at LM was well developed, which was a key factor in the implementation of EDI.

In 1988 LM began installing an EDI application based on a standardised EDI service named ‘Allegro’. LM initially aimed at improving the operational efficiency of processing its purchase orders. The availability of a third-party network and the choice for Allegro were crucial in taking advantage of EDI technology for reducing costs and lead time. By adopting a standard instead of developing an in-house solution, LM could implement its EDI application quickly, cheaply and without risk.

A barrier to diffusion was some resistance from several suppliers who were rather reluctant to adopt the system. Future developments in terms of extending the functional and geographical scope of the application would have to be based on the line drawn up by the service provider Allegro. LM expected that the success with regards to operational efficiency was likely to be repeated and extended. Yet, competitive advantage could not be achieved by using EDI, because competitors had access to the same service.
Objective setting

By whom: The middle-level IT managers.

Trigger:
- Repetitive strikes and long delivery times by the postal services. Besides, the overall ordering process was inefficient by being totally dependent on the PTT
- Some high volume suppliers had expressed an interest in EDI

Support: Unclear, however, LM seems to have good insight into developments at their market.

Criteria and constraints

Criteria: reducing paper and administrative work; reducing lead-time and inventory; reducing re-entering of data and transmission errors.

Constraints: implementation budget, availability of third-party networks and standard message sets

What: The objective was to improve the operational efficiency of processing the purchase orders.

How: Installing an EDI application for purchase orders.

Alternatives generation

By whom: IT management.

How: Unclear.

Support: Unclear.

Constraints: The implementation of the alternative must be cheap, quick and without risk.

Alternatives assessment

By whom: IT management.

How: Alternatives are assessed on the basis of the criteria: availability and use in practice.

Gencod, a private institution, could offer Gencod (a product codification standard) and Allegro (an EDI-service). Hence, LM would only have one partner instead of two if it would use Gencod’s competitor, ATLAS 400. Allegro was specially developed for the distribution sector.

The volume of transactions between two business partners determined the choice for a network. For the partners, the criteria were that EDI should benefit both the supplier and LM.

A ranking of the importance of the suppliers was made on the basis of the total number of purchase orders and the number of product lines per order.

Support: Unclear, a costs table is given, but this is probably drawn up after the implementation.

Reliability results: Only after implementation, the strategic implications were recognised and top management became involved.

Choice

By whom: IT management.

How: On the basis of the criteria the EDI alternative was chosen.

Partners were chosen on the basis of the ranking (after which...
they have to be convinced/motivated by LM).

Support: Unclear.

The decision process showed a cyclic approach: first an alternative solution was chosen, then the criteria were set, various alternatives were weighed and an alternative was chosen (Gencom/Allegro).

4.2.3 Going global with EDI? - the case of Kuehne & Nagel

Eistert and Krcmar (1995) describe the case of Kuehne & Nagel (KN), one of the leading freight forwarding companies in Europe, offering a full range of transport related services to its customers around the world. KN used a concept of global information flow management to improve efficiency of internal information exchange and to strengthen customer linkage. EDI was used in this concept and introduced in a series of projects.

The concept of information management provided the possibility to forward all information to the customer, so that considerable value added for the customer emerged as a by-product of internal information flow management. It furthermore enabled KN to enlarge the scope of activities beyond the traditional transport of goods. In that sense, KN transformed from a traditional forwarder of goods into an information services company. The concept of integrated information flows was expected to lead to a notable competitive advantage.

The central EDP department was in charge of the general information systems strategy of the group, the development of software applications and the world-wide communication links between the KN branches. This centralised department had been introduced a short time ago, while the autonomy of the regions and branches had led to a large variety of information systems throughout the group.

Objective setting

By whom: KN managers and the head of EDP department. Top management approved the project.

Trigger:
- Realisation of the internal European market; innovative competitors
- Expectations on notable competitive advantage through using EDI
- The 1988 top management strategy paper analysing the possibilities to enhance speed and accuracy of the information transfer
- Emergence of EDIFACT as the future global standard for EDI

Support: A detailed analysis of information flows within a 'model of an international freight forwarder' (which revealed many potential
efficiency improvements, especially in the domain of international information exchange).

**Criteria and constraints**

A positive organisational context enabled the set-up of a long-term project which did not require bi-annual justification. Certain assumptions on user growth (which in the evaluation stage proved to be too optimistic).

*Constraints:* for TRAFFIC a step-by-step approach was used with priorities for implementation according to the necessity of changing existing procedures (due to the very large dimensions of the project and the time frame of five years).

Facilitators: many customers in the USA; a ‘champion’ in the organisation; promotional strategy to sell EDI to KN staff and customers; innovative competitors.

Barriers: technical diversity within the KN organisation; slow progress in message standardisation; staff education and qualification needs; organisational structure; slow decision processes; integration of acquired companies and joint venture partners; changing priorities (for both KN and customers); customer hesitancy (lack of awareness of potential benefits among the customers, due to lack of knowledge or low priority given to inbound logistics).

**What**

The objective of KN was to improve the efficiency of internal information exchange and to strengthen customer linkage.

**How**

EDI in the form of a suite of four applications (KNIE, TRAFFIC, POCS and PCFACTS) was used within a global concept of information flow management to improve the efficiency of internal information exchange and to strengthen customer linkage. KNIE: communication network between KN offices and clients. TRAFFIC: administration of all forwarding activities of KN (objectives: fast information exchange via EDI within the KN organisation and with customers, integration of customers in the transport information flow, paper less documentation and communication, standardised communication structures within the KN organisation and with customers). POCS: management of purchase and information transfer to the consignee. PCFACTS: tracking and tracing of freight status by the customer.

**By whom**

EDP-department.

**How**

Unclear, although a choice for in-house development of software is made. For KNIE, a VAN was chosen, because interconnecting offices exceeded KN’s capacities and know-how. Criteria used for the choice of a VAN were: it should be
present in all countries with a KB branch office; it must offer both a network and a clearing house.

Support  Unclear.
Constraints Unclear.
Result  Various alternatives for the different parts of the projects (for example, for the VAN provider IBM and GEIS were approached.

Alternatives assessment
By whom The EDP department.
How Unclear.
Support
- No detailed cost analysis, expenses in software development have not been analysed
- For KNIE the communication costs for the network are regularly analysed. They must be compared with the savings in telefax and telephone costs
- Because business was planned to expand, no concrete calculations for staff reduction (at the level of manual data entry) were done

Reliability results Unclear.
Choice
By whom The EDP department.
How Unclear.
Support Unclear.

4.2.4 EDIfragt - the case of the Danish state railroad’s EDI system

Bjørn-Andersen and Nygaard-Andersen (1995) describe the case of DSB Freight (DF), an independent division of the Danish State Railroad. It was government owned and financially controlled through the state budget. It was under severe pressure from the government to become competitive with private enterprises. This had led to extensive internal rationalisation and the focus changed from being budget oriented to becoming business oriented.

The part-load segment of DF was handling more than 3.5 million consignment notes each year, by a daily average of 15,000 notes. The administration of consignment notes was characterised by a relatively high amount of paperwork compared to the physical volume of goods. DF had 8,000 registered part-load customers and a large number of unregistered walk-in customers. Most customers on file were small, infrequent, and irregular users of the part-load services. The 20 biggest customers were initiating 15% of all consignments handled by DF.

In order to meet the governmental requirements on competitiveness, DF started to use IT to cut costs in the handling of freight. In 1988, DF initiated the development of a new information system, called GTX, for the
handling of consignment notes for domestic part-load traffic products. This was the first step in a series of administrative systems for the various freight service types provided by DF. The system required more comprehensive data input than the former manual system. As a consequence, an EDI solution for capturing data at the earliest possible time was considered already when GTX was in the planning phase.

**Objective setting**

**By whom**
For GTX, DF top management.
For EDIfragt the operational management of DF.

**Trigger**
Severe pressure from the government to become competitive with private enterprises.

**Support**
Awareness of EDI had been created through the work on standardisation of communications procedures in the international forum for national train organisations.

**Criteria and constraints**
- **Criteria:** development and future maintenance (of EDIfragt) should be as simple as possible. For the intended pilot project, a large customer was sought with known IT experience.
- **Constraints:** unavailability of the required EDIFACT standards (due to the fact that DSB Freight was a very early first mover); large customers were not ready to commit the necessary resources required to integrate EDI with their existing IS. But working with standards is also a necessary part of the co-ordination across organisations and national borders (which was seen as a precondition for well-functioning national and international train traffic).

**What**
Extensive internal rationalisation activities; focal change from budget orientation to business orientation (strategic).

**How**
Development of a new information system for the handling of consignment notes for domestic part-load traffic products (GTX).
Use of EDI (for capturing data at the earliest possible time) for external information exchange (EDIfragt as a first step in a series of EDI solutions). The original goal for EDIfragt was to have 65% of all consignment notes handled on the system.

**Alternatives generation**

**By whom**
Internal and external experts (DSB Freight, DSB data processing centre). The functional specification was developed in co-operation with managers from the DSB freight division, external software houses, the VAN-provider DanNet and Philips Denmark A/S, a large part-load customer. The team was characterised by extensive knowledge of IT, EDI and the business in general.

**How**
The criteria and constraints led to a search for standard EDI software operating on an open platform, an external VAN
provider, a dedicated EDI server and use of a standard which was most developed and attractive to a large group of customers (the HANCOM standard).

Support Unclear.
Constraints The development of GTX was budget controlled; a careful planning for the EDIfragt project (as a further development of the GTX system) was made.
Result A single alternative was worked out.
By whom The same group which generated the alternatives.
How The initial benefit estimation was based on the expected savings in the internal administration related to the handling of consignment notes. EDIfragt was expected to level peak hours (at the freight terminals) and to eliminate errors. Next, expectations on reductions of typing errors and misinterpretation by re-using data from the customer’s internal information systems were stated. It was estimated that 10 to 20 of the largest part-load customers would have to use EDIfragt in order to balance the cost. The payback period was estimated to be approximately two years. The estimation was focused upon rationalisation effects: 67% came from a reduction in human resources required for re-keying data, 13% due to paper savings and 20% due to more efficient use of computer (mainframe) processing time).

Support No formal means for cost assessment was used by DSB Freight.
Reliability results After implementation of EDIfragt, the great marketing value became apparent. Implementation was technology driven and came from operational management, the strategic use was recognised afterwards. The strategic impact was represented by the possibility to offer a differentiated service to the customers compared to the competitors. Furthermore, a locking of customers took place and the relations were developing into a kind of partnership, which was of convenience to both parties.
Choice Because in the alternatives generation process actually only one alternative was generated and further developed, choice became trivial.

4.2.5 DANZLINK and beyond - the case of Danzas

Schalch and Griese (1995) describe the introduction of EDI at Danzas, one of the leading freight forwarding companies in Europe. The company’s main task concerned the organisation of shipments. It had a highly decentralised and fragmented IT infrastructure. In a step-wise manner the organisation grew into the use of EDI. The stages of evolution of the Danzas network were determined by different technical approaches and a growing
awareness of the strategic importance of information and communication technology use in the forwarding business (not only for internal use, but also for links with customers). Two steps are discussed here:

1. The introduction of Danznet for internal electronic data interchange.
2. The evolution towards Danzlink. Danzlink was a PC based order entry system for customers for the connection with Danzas.

### Objective setting for Danznet

<table>
<thead>
<tr>
<th>By whom</th>
<th>European Management Committee.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger</td>
<td>Not all Danzas country groups could be connected to the DEC network (which was previously established)</td>
</tr>
<tr>
<td></td>
<td>The system was not based on an open standard</td>
</tr>
<tr>
<td>Support</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Criteria and constraints</td>
<td><strong>Criteria:</strong></td>
</tr>
<tr>
<td></td>
<td>the system should be based on an open standard</td>
</tr>
<tr>
<td></td>
<td>potential reduction of redundant data input</td>
</tr>
<tr>
<td></td>
<td>major decrease in transfer costs</td>
</tr>
<tr>
<td></td>
<td>a considerably reduced error rate during order transaction</td>
</tr>
<tr>
<td></td>
<td>a presumable cut down in transport time</td>
</tr>
<tr>
<td></td>
<td>the possibility to make arrangements ahead of time</td>
</tr>
<tr>
<td></td>
<td>saving on handling time</td>
</tr>
<tr>
<td></td>
<td>the possibility to handle customs declarations even before the arrival of a shipment at the border</td>
</tr>
<tr>
<td><strong>Constraints:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the system would initially be for internal use only</td>
</tr>
<tr>
<td></td>
<td>a deadline for the European country groups to establish the necessary technical means to start with data communication</td>
</tr>
<tr>
<td></td>
<td>data elements had to be constructed along the UNTED-ISO norm 7372</td>
</tr>
<tr>
<td></td>
<td>syntax for data interchange had to meet the norms of TDDI-EDIFACT</td>
</tr>
<tr>
<td></td>
<td>data transportation had to use X.25</td>
</tr>
<tr>
<td></td>
<td>for economic reasons, the country groups were allowed to exclude the smallest offices from the network</td>
</tr>
</tbody>
</table>

### What

An important objective (statement) of Danzas was: ‘Quality improvement through standardisation’. Top management of Danzas was convinced that EDI would soon become a strategic necessity and also convinced of the long-term success of international standards like EDIFACT. Therefore, first priority was given to meet all information and communication needs. Objective: the establishment of a world-wide communication system allowing any Danzas branch interchange data independent of its hardware (since competitors lacked such as system, a skilled use of all the factors involved would enable
Danzas to differentiate).

**How**
By executing a project to create an internal electronic data communication network.

**By whom**
The working group 'data communication'.

**How**
A message design group was established, which had to convert the standards of data interchange, set up by the data communication group into corresponding EDIFACT messages.

**Support**
The message design group was chaired by a Danzas EDIFACT specialist.

**Constraints**
Unclear.

**Result**
A single proposal, containing the constraints mentioned under objective setting.

**Alternatives assessment**

**How assessment of alternatives for Danznet took place is unclear.**
Because in the alternatives generation process actually only one alternative was generated and further developed, choice became trivial.

The executive committee of Danzas initially decided to restrict Danznet to internal use because

1. external accessibility of Danznet was seen as a future development
2. the improvement of internal communication was given priority
3. a set of (legal) rules would have to be determined before opening Danznet to third parties
4. Danzas did not want to establish bilateral protocols (i.e. all customers should be connected, or no customer at all. Just a few customers could stir negative feelings among excluded companies)

Yet, there would be advantages for customers in joining Danznet:

- faster and simpler processing of transport orders
- lower error rate (as opposed to orders over the telephone)
- reduced waste of paper
- further automation by linking the data to internal information systems

This advantages led to development of Danzlink.

**Objective setting for Danzlink**

**By whom**
Sales departments of the country group Switzerland, supported by the Swiss executive committee.

**Trigger**
Market pull for the possibility to transmit consignment notes and status data electronically (caused by developments of other forwarders/competitors and in Switzerland by the pioneering of the Swiss customs).

**Support**
Unclear.

**Criteria and constraints**

- **Criteria:** use open and well-known standards.
- **Constraints:** customers cannot join Danznet.

**What**
Provide customers with an instrument enabling them to use the advantages of EDI and distribution logistics in a simple way.
How

Development of Danzlink, a PC based order entry system for customers for the connection with Danzas.

By whom

The sales department and IS group of the country group Switzerland.

How

Unclear.

Support

Danzas officials were part of the Swiss Freight Forwarders’ Association (SFFA) that set the standards for forwarding orders.

Constraints

Unclear.

Result

A single alternative was presented.

By whom

Management of the Swiss Danzas branch.

How

Unclear.

Support

Unclear.

Reliability

Unclear.

Because in the alternatives generation process actually only one alternative was generated and further developed, choice became trivial.

### 4.2.6 An association’s leadership for industry-wide EDI - the case of AECOC

O’Callaghan and Eistert (1995) describe the case of AECOC, a Spanish trade association (i.e. a group of manufacturers and distributors of consumer goods). It was trying to integrate the interests of its members and the international EAN organisation of which AECOC was an associate. AECOC was an active promoter of the use of EDI in the Spanish retail sector and pushed the use of its EDI service AECOM which was based on a common format for the consumer goods distribution in Spain. The objective of AECOC was to catch up with international developments and to prevent isolationist tendencies that had occurred in other countries. The diffusion of AECOM was inhibited by organisational inertia and cultural barriers of potential trading partners. Awareness-raising actions and extensive training were expected to help overcome these barriers. Due to its neutrality and high credibility in the industry, AECOC was able to undertake these actions. The history of AECOM, the EDI service can be described in five phases.

1. In 1985, a discussion on potential benefits of standardisation of business documents and processes begun. A committee with representatives was formed which agreed on standardisation of several messages. This changed when the EDIFACT standard was adopted by ISO. The idea emerged to exchange documents on a common language format through electronic means;

2. A special committee was set up to establish the objectives and requirements for AECOM. The EDI service was to be based on
communication between a central server station and individual user workstations. The latter ones had to be user friendly, easily accessible and inexpensive.

3. In the third phase, in 1989, the appropriate partners for the development of an EDI platform including hardware, software and the telecommunications network were sought. 15 companies applied, of which four appeared on a short list. The special committee also got involved in the process of selecting vendors of software. The Spanish PTT was chosen, hoping to have a greater leverage and a better service if a national service provider was chosen.

4. A pilot was implemented in 1990, with 12 manufacturers and distributors. Small and large companies were equally represented. A lot of publicity was generated to prepare for a fast growth in terms of the number of users and volume of transactions in the months to come.

5. After the pilot, a large-scale introduction took place and AECOM use grew to 180 companies by July 1992.

### Objective setting

<table>
<thead>
<tr>
<th>By whom</th>
<th>AECOC board of directors, special committee.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger</td>
<td>Developments of common business formats in other countries.</td>
</tr>
<tr>
<td>Support</td>
<td>AECOC was member of the international EAN organisation.</td>
</tr>
</tbody>
</table>
| Criteria and constraints | - for use: fast user growth  
- for the messages: use EDIFACT standard messages  
- for the user workstation: user friendly, easily accessible, inexpensive  
- for the VAN provider: potential leverage and high service level  
- for the software vendors: “many criteria” |
| What            | Introduce a standard format for business documents and the electronic exchange and make this the industry-wide standard. Its aim is to rationalise inter-company communication. |
| How             | Development and introduction of AECOM. |

### Alternatives generation

<table>
<thead>
<tr>
<th>By whom</th>
<th>The special committee.</th>
</tr>
</thead>
<tbody>
<tr>
<td>How</td>
<td>By discussions and opening a tender for offers on the development of an EDI-service.</td>
</tr>
<tr>
<td>Support</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Result</td>
<td>A final short list with four companies who applied to the project.</td>
</tr>
</tbody>
</table>

### Alternatives assessment

<table>
<thead>
<tr>
<th>By whom</th>
<th>The special committee.</th>
</tr>
</thead>
<tbody>
<tr>
<td>How</td>
<td>On the basis of the criteria set.</td>
</tr>
<tr>
<td>Support</td>
<td>Unclear.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Given the encountered problems, not all relevant aspects were taken into account.</td>
</tr>
<tr>
<td>results</td>
<td></td>
</tr>
</tbody>
</table>
Choice

By whom  AECOC board of directors, special committee
How   In the use of EDI, first a choice was made for easy-to-integrate messages within the administrative systems (invoices are easier than purchase orders because the latter ones imply involvement and integration of many applications).
Support  Unclear.

Problems which were encountered in the introduction of AECOM stemmed from technical difficulties, due to network problems, frequent changes in software and the user interface (in the early stages of the project), changes in the EDI messages (because the common language format itself was still evolving), the fact that only a PC-solution was available and the communication link options were limited. The system eventually evolved to more open solutions with regard to software, hardware and communication. Other issues which had to be overcome were:

- Legal constraints: VAT handling required a paper-based invoice document.
- Acceptance among AECOC members was a problem due to the reluctant attitude of many companies, they had not clear plans to use and integrate available EDI and the largest chain of department stores used a proprietary system.

4.3 Observations

In this section we present our observations derived from the cases, as well as the observations by Bjørn-Andersen and Krcmar (1995) which they based on a cross-analysis of all cases in “EDI in Europe”. It is probably possible to derive other conclusions and hypotheses from the observations, but we limit the conclusions to the development of COMET. After each observation we present the implications for COMET, which may serve as requirements.

4.3.1 Objective setting

In the cases, the investment was mostly a reaction to an external development (threat). Bjørn Andersen and Krcmar (1995) observe that almost all organisations involved in the cases were convinced that EDI had resulted in a win-win situation with the EDI partners, but no one responded that it had led to strategic partnerships with the EDI partners. Furthermore, the EDI projects were mainly used for improving existing business relations and not for creating new business opportunities.
Implications for COMET

We think that decision-makers should not just react to environmental developments, they should also try to foresee which developments will occur (cf. Bjørn Andersen and Krcmar, 1995). Besides, decision-makers should analyse the organisation on its strengths and weaknesses. Besides supporting the analysis of environmental threats and organisational weaknesses, COMET should also support the analysis of environment for opportunities and the organisation for strengths. In other words, COMET should contain methods to execute a complete SWOT analysis.

In the cases we observe that often middle and higher management took the initiative for new project proposals and set the objective. Groups execute all the different processes in the decision process. The groups who eventually decided on the projects were not always the ones who set the objectives, generated alternatives, or assessed the alternatives. This makes good communication between the groups crucial.

Next to that, Bjørn Andersen and Krcmar (1995) observe that the projects were most often planned in a top-down fashion. Despite this, both within and between activities in the decision-making process, several parties were involved. They should have a common language to overcome possible misunderstanding.

Implications for COMET

The cases show that many people are involved in the various stages of the decision process. We think it is healthy for organisations to have initiatives coming from all parts of the organisation, but project sponsors at the higher management levels are necessary as well (cf. Bjørn Andersen and Krcmar, 1995). In order to convince higher management, projects must be presented in their ‘language’.

COMET should be able to support the different groups by means of a clear structure or format and by methods which the respective groups understand. If we consider COMET to be a support mechanism for group decision-making, a presentation of the methodology as a tool can be used to structure the processes.

Moreover, when different groups are involved in different stages of the decision process, COMET should support a proper (that is: clear and unambiguous) transfer of information and knowledge from one stage to another.
4.3.2 Alternatives generation

Large organisations more or less grew into the use of EDI, according to a stepwise approach. Practically all organisations had started with replacing in-house manual processes by electronic ones. Then an extension was made towards the replacement of external manual information processes by electronic ones. Another reason for a stepwise approach was that the total sum of the investment was too large.

Implications for COMET

COMET should recognise the fact that the introduction and implementation of telematics investments may follow a step-wise path, making future investments build on past or current investments. COMET should support decision-makers in recognising and determining these dependencies.

We suggest that when organisations lack experience with (large) telematics investments, an evolutionary approach is appropriate to gain learning experience and to lower the risk of failure.

In general, the parties involved in the cases deployed two growth strategies or a combination of the two: expansion of the number of partners involved or expansion within the set of messages to exchange. Moreover, cooperation was often sought with well-known (large) partners. This led to delays and/or problems in the expansion strategy after the pilot or implementation stage of the project.

When organisations decide to invest in telematics on a small scale after which an expansion may occur, it appears to be necessary for decision-makers to project future roll-out scenarios.

Implications for COMET

The implications for COMET from this observation are basically the same as from the previous observation. COMET should support the projection of (consequences of) the investment into the future.

4.3.3 Alternatives assessment

Probably due to the operational objectives set, criteria often reflected efficiency considerations (reduction in paper waste, reduction in manual error checking, etc.). Although the criteria have a quantitative nature and are the ones easiest to express in monetary terms, all parties refrain from performing a formal cost-benefit analysis. The assessment was either performed loosely, informally or unstructured, or it (unfortunately) remained unclear. Besides, the organisations described hardly make use of existing assessment methods.
Bjørn Andersen and Krcmar (1995) observe from the cases that performing a narrowly focused cost-benefit analysis leading to a positive result and related with a view on the strategic perspective, provides a good basis for the introduction of EDI. They conclude that if formal analysis had not been carried out, some kind of justification of the investment should have been performed in all organisations.

**Implications for COMET**

Many organisations express having difficulties in valuing investments in telematics. Given the observations above, this seems obvious: no clear analysis is made. When decision-makers want to make a solid decision on telematics, they have to perform an analysis of the costs and benefits.

The results of studies by Farbey et al. (1992) also indicate that a thorough financial analysis of IT investments in practice hardly takes place. According to Willcocks and Lester (1994), the respondent organisations in their study were (very) satisfied with their evaluation procedures. Yet, a careful analysis of evaluation practice by the authors revealed that this satisfaction was widely misplaced. Organisations may be missing telematics opportunities, but also taking large risks, by using narrow evaluation approaches that do not clarify and assess less tangible inputs and benefits (Willcocks and Lester, 1996).

The observations can have multiple implications for COMET. First of all, theory emphasises that performing an assessment is fruitful in any case. Secondly, an assessment of the quantifiable costs and benefits is a good starting point, while most decision-makers first seek justification of an investment in its quantifiable aspects. However, decision-makers may thus miss other important effects. Extension of quantitative analyses with analyses of qualitative effects seems to be in place.

To both meet the assessment demands and maintain freedom for the decision-makers to choose a certain assessment method, COMET should offer a range of assessment possibilities.

Given the problems encountered in some cases, not all criteria which could have been thought of and assessed had been taken into account. Bjørn Andersen and Krcmar (1995) observe that the majority of the organisations had no clear vision of the long-range implications of the project. Next to that, organisations had no clear picture of the technical complexity, the case with which it was possible to establish the necessary organisational changes and the potential diffusion rate among trading partners. The researchers furthermore observe that costs and tangible benefits get higher average rankings by organisations which perform EDI from an operational view than the organisations with a strategic objective. Yet, although the initial rationale for most organisations can be found in the creation of tangible
benefits, in an evaluation with the companies involved, the group of intangible benefits is rated higher than the group with tangible benefits (Bjørn Andersen and Krcmar, 1995).

**Implications for COMET**

In order to make explicit for what reason (objective) the investment should be performed and to gain full understanding of the impact of the telematics investment, all relevant decision criteria should be made explicit. The implication for COMET is that it should suggest decision criteria which can be used and/or support a structured approach in deriving decision criteria from the investment objective.

All parties who took the initiative for the EDI exchange saw the projects and initial pilots as clear successes. However, this does not say anything about the track towards full electronic data interchange of all messages with all partners. Even stronger: within certain cases some problems already appeared (Technische Unie, AECOC) when an expansion of the number of business partners involved was sought. Often, the target for the projects are set at full electronic exchange of a certain message set with all partners, which afterwards mostly proved to be too ambitious. Bjørn Andersen and Krcmar (1995) also observe that the ambitious objectives for cost reduction, user and transaction growth after the pilot, or the time frame for the implementation have not all been reached.

**Implications for COMET**

It seems that the organisations where too optimistic in their expectations on the results (Bjørn Andersen and Krcmar, 1995). This will partly be caused by the fact that no proper analysis and projection of the results is made. Another reason will be that organisations have paid too little attention to external dependencies.

The implication for COMET is that it should trigger and support proper assessment of alternatives, provide tools to indicate external dependencies and support the generation of realistic targets.

**4.3.4 Other**

Support for selection mainly came from experience with other automation projects. This learning experience is very important to telematics projects and should be kept within the organisation. Yet, in knowledge-creating organisations and in many service organisations, experience is ‘stored’ within human beings. To make full use of the available knowledge, other forms of retaining knowledge within the organisation are necessary.
Implications for COMET
Experience appears to be important as support in the decision process. To prevent experience from being stored solely in the heads of employees, COMET itself should have a mechanism to capture and hold experience gained in previous stages of the decision process and in previous projects.
Existing support for investment decision-making

In the previous chapter, decisions on telematics investments in the practice of six cases are explored. It appeared that decision-makers hardly use supporting methods. Given the vast amount of methods that exist, this seems odd. In this chapter we study those methods, not only on their merits, but also on their usability in practice.

By using the decision process model introduced in chapter 2 as a starting point, we are able to classify and analyse current methods. We introduce an analysis framework in section 5.1. For the stages objective setting, alternatives generation and alternatives assessment we analyse existing methods (sections 5.2 - 5.4). On the basis of the analysis we derive conclusions which can lead to requirements for COMET. These can be found in section 5.5.

5.1 Analysis framework for existing methods

A host of methods to support investment decisions already exists. To be able to assess the merits and weaknesses, and to identify possible omissions, we use an analysis framework in which the methods can be compared, see Table 5.1. The methods are analysed with the aspects represented in Table 5.1 for the different stages in the decision process.
Table 5.1 Analysis questions for investment decision support methods

<table>
<thead>
<tr>
<th>Analysis Questions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What</td>
<td>what is the method's aim?</td>
</tr>
<tr>
<td>How</td>
<td>how does the method work?</td>
</tr>
<tr>
<td>Who</td>
<td>which parties (stakeholders) should use the method?</td>
</tr>
<tr>
<td>Inputs</td>
<td>what inputs are necessary for working with the method?</td>
</tr>
<tr>
<td>Outputs (+ reliability)</td>
<td>what are the results of the method and do the actual results comply with those results?</td>
</tr>
<tr>
<td>Theoretical support</td>
<td>is the method based on a theory and what are the consequences of that theory for the method and its results?</td>
</tr>
<tr>
<td>Combination possibilities</td>
<td>can (or should) the method be used in combination with other methods?</td>
</tr>
<tr>
<td>Use in practice and (dis)advantages</td>
<td>are there (many) organisations which actually make use of the method and are practical pros and cons encountered in the use of the method and what are these advantages and disadvantages?</td>
</tr>
</tbody>
</table>

Existing methods do not necessarily support one stage within a decision cycle. Some methods will cross the stages as depicted in Figure 5.1.

![Figure 5.1 Support methods will not always exactly map onto the decision stages](image)

In the next sections we present the results of our analyses. Given the scope of our research we cannot evaluate all methods currently available. We have chosen methods which are commonly accepted as being representative. We conclude the sections by giving observations and conclusions, which can serve as inputs for the requirements for COMET.

## 5.2 Methods to support objective setting

The methods to support objective setting vary from simple heuristics and rules of thumb to sophisticated, computer supported decision tools. Table 5.2 sums up some important and well-known methods. It is, however, not exhaustive. For a more elaborate overview of methods and tools we refer to Robson (1997).
Table 5.2 Methods for objective setting

| Critical Success Factors analysis (Rockart, 1979) |
| Five forces framework (Porter, 1980) |
| Value chain analysis (Porter, 1985) |
| Strategic importance matrix/Boston Consultancy Group matrix (McFarlan and McKenny, 1983) |
| SWOT analysis (see Robson, 1997) |
| Scenario planning (Clemons, 1995; Schoemaker, 1995; Van der Heijden, 1996) |
| Five-level framework of IT-enabled business transformation (Venkatraman, 1991, 1994) |

5.2.1 Critical success factors analysis

What
The critical success factors analysis (CSF), as developed by Rockart (1979) is a top-down approach intended to gain insight into the strategic information requirements of the organisation. This concerns the information needed to operate and manage an organisation. CSF concern those factors that must go right for an organisation to be successful and should be under constant scrutiny of management.

How
The CSF approach contains three steps: first, the CSF have to be articulated, then key decisions related to the CSF have to be determined, which on their turn determine the information requirements. The analysis allows managers to determine their need in terms of information which is critical to them. These information requirements are used to identify the critical areas of IT effort and expenditure. CSF are specific to an organisation, the industry, as well as the time period in which it operates.

Who
The CSF can be used to minimise the gap between user management and IT management. As such, the CSF should be comprehensible for management and IT management, while it must be possible to act upon them.

Inputs
A decision-maker has to take account of the circumstances which influence the CSF. Robson (1997) points at the following issues which need to be addressed:

- the industry in which the organisation is active
- the competitive strategy and market position
- environmental factors, such as the general economic situation, politics
- temporal factors
- managerial position; the CSF will vary with the level in the hierarchy.
CSF are related to each other: market CSF will influence the CSF of an organisation, which on their turn influence CSF of departments or processes. A CSF analysis to find out strategic information requirements should be performed after the general business objectives are determined (Ward and Griffiths, 1996).

**Outputs**

Output of the analysis is a handful of factors which are crucial to the success of the organisation. They can be used as a basis to adjust objectives or determine new objectives.

**Theoretical support**

CSF is based in strategy literature. Many authors have contributed both to theory and to the body of knowledge with relation to CSF in practice.

**Combination possibilities**

CSF can easily be combined with other methods which support decision-making. A combination is also necessary, while CSF alone do not give enough insight to base investment decisions on.

**Use in practice and (dis)advantages**

CSF are widely used in practice (Robson, 1997). The advantage of CSF analysis is that it keeps focus upon strategic issues and provides support for planning since it leads to insight into the critical activities of the organisation. The analysis can be used as a starting point for further structured analysis. A weakness of the analysis is that it needs very skilled and perceptive interviewers to derive the CSF from management. Another weakness is that managers who are not directly involved in strategic planning often find the approach too conceptual. Besides, it is very difficult to obtain a true picture of the information requirements by only using CSF.

### 5.2.2 Five forces framework

**What**

The five forces framework makes it possible to determine where in the organisation's transactional environment opportunities and threats for the organisation can be found. The transactional environment is that part of the environment in which the organisations is an important player and mutual influence of organisation and playing field exists (Van der Heijden, following Emery and Trist, 1996).
**How**
By breaking the environment up into five parts, an organisation is forced to think about each part separately, which lowers the possibility of forgetting aspects (see Figure 5.2). Organisations should make a detailed research of each of the areas within its environment. This will take serious effort, but makes it possible to choose for the most important threat or opportunity to concentrate upon.

**Who**
If the analysis of the environment is used to support strategy setting, management should be involved.

**Inputs**
To make a good model of the competitive forces which are present in the sector, the organisation should perform a detailed research into its sector. Examples of factors influencing each of the five forces which should be considered are given below.

*Rivalry among existing firms* can range from mild to very intense. In sectors where rivalry is high, profits will tend to be under constant pressure.
Factors which influence this competitive force are: growth of the sector, existing over-capacity, product differences, brand identity and switching costs for customers, granularity of the sector, diversity of competitors and the existence of high exit barriers.

*Bargaining power of suppliers* is influenced by the uniqueness of inputs, switching costs for the organisation of changing to an alternative supplier, the availability of substitute supplies, supplier concentration and the importance of the volume to suppliers.

*Bargaining power of buyers* is influenced by buyers’ price sensitivity and bargaining leverage. Price sensitivity of buyers can be reduced by a creating brand loyalty and differentiation. The bargaining leverage of buyers is
influenced by their concentration and volume purchased, their switching costs, threat of backward integration and the existence of substitutes.

The threat of new entrants is influenced by the barriers within the market and the persistence of new entrants to overcome those barriers. Factors relating to this threat are government policy, expected retaliation, absolute cost advantage, access to distribution channels, switching costs for buyers, economies of scale, product differentiation and brand loyalty and capital requirements.

The threat of substitute products or services is influenced by the availability of substitutes and factors such as the relative price and performance of substitutes, switching costs and the buyers' propensity to switch to the substitute.

**Outputs**

Outputs of the five forces framework are indications of opportunities and threats which are related to the five dimensions. The results can be used as input for the determination of the competitive strategy.

**Theoretical support**

The method is based in theory on strategy. It is a commonly accepted approach and often forms part of other methods (for instance in scenario planning or SWOT analysis).

**Combination possibilities**

The method gives insight into the external environment of the organisation. The analysis should at least be supplemented by an analysis of the strengths and weaknesses of the organisation itself.

**Use in practice and (dis)advantages**

The method became very popular in the eighties. Whether it is currently in use in practice is unclear. An advantage of the method is its clear approach. A disadvantage of the model is that, although it suggests an exhaustive analysis, it does not take into account all forces at the market. For instance, governmental actions, relations with money providers such as shareholders and banks, as well as activities of pressure groups are not taken into account. Decision-makers should be aware that the method aims at an environmental analysis, which paint only half the picture for objective setting; an analysis of the organisation is necessary as well.
5.2.3 Value chain

What
An organisation should not only examine the environment on opportunities and threats, it should also be aware of its own capabilities. Insight can be gained by auditing the organisation. A common approach is to structure the internal organisation in terms of a collection of activities or processes. By using the value chain, developed by Porter (1985), it is possible to (visually) gain insight into the various business activities (see Figure 5.3). Porter assumes that organisations strive for competitive advantage. He suggests that competitive advantage cannot easily be derived from looking at the organisation as a whole. Competitive advantage is generated by many (separate) activities. The value chain is a systematic approach to analyse how organisational activities function and how they influence each other. Aim of the analysis should be to configure a value chain which is different from those of competitors or to have cost advantages over the competitors for certain activities.

The value chain is part of the value system. The value system comprises the value chain of the organisation under consideration, as well as the chains of its partners, which can are its suppliers’ and customers’ value chains. The value system allows the analysis of the creation of value at the level of organisational networks.

How
By modelling the activities of an organisation it is possible to distinguish primary activities, those that directly are related to creation of goods or services, and secondary activities, those activities which support the primary activities. By analysing each activity, its effectiveness and efficiency in resource use can be determined. Kaplan and Norton (1996b) suggest an activity based costing approach to gain insight into the process costs.
Who
If the analysis of the organisation is used to support strategy setting, management should be involved.

Inputs
The inputs for the value chain analysis are data on activities. It concerns descriptions of the activities, relations with other activities, output and resource use.

Outputs
The output of the model is an analysis of the organisation at activities level, which gives a view at areas where potential improvements can be made.

Theoretical support
The method is based in theory on strategy. It is a commonly accepted approach and often forms part of other methods (for instance in scenario planning or SWOT analysis).

Combination possibilities
The method should be combined with a method which analyses environmental developments, for instance the five forces framework.

Use in practice and (dis)advantages
The method became very popular in the eighties. Although still often referred to in literature, it is unclear whether the method is currently in use in practice. An advantage of the method is its clear structure which forms a guideline for the analysis.

5.2.4 Strategic importance matrix/Boston Consultancy Group matrix

What
On the basis of the Boston Consultancy group matrix (BCG), McFarlan and McKenny (1983) developed a strategic importance matrix. The BCG matrix classifies products or business units according to their market share and the future growth potential of the particular market at which they are present. By positioning the products or business units in the matrix (star, wild cat, dog or cash cow), decision-makers can determine the prescribed actions which are related to each of the cells within the matrix.

How
The strategic importance matrix makes a classification possible along the lines to which the organisation is currently dependent on information systems and the degree to which IT developments will create competitive
advantage. It thus determines the criticality of existing systems and the extent to which they will be critical in the future. We represent the matrix as Table 5.3. Within each cell we added between brackets the indication used within the BCG matrix.

Table 5.3: Strategic importance matrix (taken from Robson, 1997)

<table>
<thead>
<tr>
<th>Strategic importance of planned IS</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>High potential (wild cat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic (star)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support (dog)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory (cash cow)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Strategic importance of current IS

The suggested actions for every segment are very general and need to be made specific for the particular circumstances in which the organisation operates. Not only the organisation can be positioned in the matrix, it can also serve to classify the information systems available in the organisation. The type of importance should be measured and described in business terms to determine the business value. The business value should determine IT resource allocations. The importance of systems may change over time, making placement in a different segment necessary. As a consequence, the analysis should be regularly performed.

Who
The analysis should be performed by management. While the analysis concerns the organisational dependency on IT, it is useful when representatives of the IT department and user departments are involved as well.

Inputs
Information on current activities of the organisation and their dependence on IT, information on planned IT and projected future dependence of the activities to IT.

Outputs
Business in the strategic segment of the matrix currently depends on IS for its competitive position and is expected to continue to do so. Suggested action to be taken by the decision-makers is to keep investing in those systems. The business positioned in the high potential cell currently does not depend very much on IT, but will be in the future. Suggested action to be taken by the decision-makers is to closely examine the possibilities of the business and the support possibilities of IT. IT is important to the business in the factory segment (the business cannot operate without it), but it is expected not to be a strategic factor by which the business can differentiate in the future. The suggested action to be taken is to ‘milk’ IT, in other words, to fully exploit the capabilities. IT is and will not be important for competitive
advantage of business in the support segment, although it can ease the operation. Suggested action for decision-makers is not to invest.

**Theoretical support**
The method is based in theory on strategy. The BCG-matrix is a commonly accepted approach and used for many aspects of business.

**Combination possibilities**
The matrix forms a basis to quickly gain insight into dependencies on IT and potential possibilities of IT. A more in-depth analysis should follow.

**Use in practice and (dis)advantages**
The BCG-matrix is very often used in practice. For the strategic importance matrix this is unclear. An advantage is that the matrix can be used to quickly gain insight into the current and near future status and role of IT and to make this role explicit. The matrix only gives a global indication of the importance of IT and cannot be a basis for decisions. One can also doubt the usefulness of the advice, in particular where the matrix suggest not to invest.

### 5.2.5 SWOT analysis

**What**
The SWOT analysis is used to find out the Strengths and Weaknesses of the organisation as well as which Opportunities and Threats occur within the (future) environment.
- A strength is an aspect of the organisation by which the organisation can positively distinct itself from its competitors.
- A weakness is an aspect of the organisation at which the organisation does not sufficiently perform.
- An opportunity is a development in the external environment of the organisation which the organisation may utilise to strengthen its position.
- A threat is a development in the external environment of the organisation, which the organisation should either prevent or anticipate, while it threatens the position of the organisation.

**How**
A SWOT should be seen as a checklist, of which each of the four elements can be seen as a question. The questions need to be made operational by a series of sub-questions. SWOT can be used to focus attention on certain issues and does not give clear guidance on how to take action (Robson, 1997). A SWOT-matrix can be developed, as given in Table 5.4.
The SWOT-matrix can give leads on a strategy to follow. Rowe et al. (1994) suggest four strategies: exploit, search, avoid, confront. The exploit strategy is to use the organisational strengths in order to handle opportunities. Business objectives are to reduce internal weaknesses and to overcome external threats. The search strategy is intended to minimise weaknesses and to maximise the use of opportunities. Opportunities are available for the organisation, but need a strength to be exploited, while the organisation shows some weaknesses in the particular area.

Who
The SWOT analysis should be performed by management.

Inputs
To find an answer to the four questions, organisations can make use of other analysis methods, for instance, a combination of the five forces framework and the value chain.

Outputs
The analysis results in a list of strengths and weaknesses of the organisation and threats and opportunities which stem from the environment. Next to that, indication for the strategy to follow can be given.
- A strength can be a unique process, high quality employees, a strong brand name, etc.
- A weakness can be caused by the use of standard processes, making products which hardly differ from competitors, a weak IT infrastructure, etc.
- Opportunities can take on different forms: they can be technological developments, such as the rise of the Internet, they can be legal and political developments, such as the integration of the European Community, they can be economic developments, such as the prosperous growth of the economy in Europe and the United States during the nineties.
- Many environmental threats exist. A current example is the year-2000 problem in software, obliging organisations to react and act. Other
examples are the economic crises in Asia and Russia of 1998 and the uncertainties they cause.

**Theoretical support**
The method is based in theory on strategy. It is a general approach which can be applied within decision processes on many sorts of investments.

**Combination possibilities**
The SWOT analysis is a very general approach, which can be executed through other methods, but which itself can also form part of other methods, such as scenario planning.

**Use in practice and (dis)advantages**
The method is commonly used in practice and widely accepted. Due to its general character it is broadly applicable.

5.2.6 **Scenario planning**

**What**
Organisations operate in ‘turbulent environments’ (Emery and Trist, 1965). Not only the decisions of individual organisations, but also the interactions between them produce unpredictability. A way of handling uncertainty with regards to future developments in the environment is the development of scenarios. Two environment categories are usually distinguished (Van der Heijden, following Emery and Trist, 1996):

- *The contextual environment*. This is the part of the environment which significantly influences the organisation, but which can hardly be influenced by the organisation.
- *The transactional environment*. In this part of the environment, the organisations is an important player and mutual influence of organisation and playing field exists.

Instead of forecasting future changes in the environment, decision-makers can develop a range of equally plausible ‘futures’. Forecasting is appropriate for relatively stable environments in which slow incremental change takes place. In such situations, predictability is relatively high. Scenarios are useful in situations in which uncertainty is high, but still a level of predictability exists. Scenarios are useful in the development of organisational strategy.

**How**
The following steps in the development of scenarios have to be taken (Schoemaker, 1995; Van der Heijden, 1996):

-
Define the scope of what the scenarios should be addressing. Elements are the time scale, products, markets, geographic areas, technologies, etc.

Gather data on the elements determined by the scope. This can be done by interviewing key persons in the organisation, market scans, desk research, Delphi surveys with experts, etc.

Perform a data analysis. The information gathered in the previous step will be highly unstructured. As a first structuring step, an "iceberg analysis" (Van der Heijden, 1996) can be performed. The iceberg breaks down knowledge in events, patterns and structure. With this analysis, an underlying structure can be sought by inferring trends and patterns in events which are observed. By clustering data in groups, a structure can emerge. Clustering can be based on patterns, cause and effects, relations, etc. Then, the clusters need to be studied to find out what the driving forces are. These forces are those variables that have high explanatory power in relation to the data in the clusters (Van der Heijden, 1996). Part of this analysis should be a study of the historical behaviour of important variables. By looking back in the past as far as the scenarios will look forward, a continuation of trends can be ensured. Activities to be performed in this step are:

- specify important events: issues that we can see.
- discover trends: time behaviour of events, which can lead to the development of variables.
- deduce patterns, based on cues for causal relations between variables.
- develop theories which connect the set patterns (different interpretations of patterns lead to different structures.

Structure a limited number of scenarios. After the data analysis, a limited set of scenarios can be constructed. Van der Heijden (1996) suggests an inductive, deductive or incremental approach. In the inductive approach, the scenario is built step by step on the data available, from which the structure of the scenario emerges. In the deductive approach, first an attempt is made to deduce an overall framework to start with, after which the gathered data is fitted into the framework. The incremental method is useful for organisations which have little experience with scenario planning. In this method, the future as foreseen by the organisation is taken as a starting point and the scenarios are based on it.

Develop story lines for the scenarios. Once the structure of the scenarios is generated, they have to be translated into appealing and logical stories. The scenario planners may use a lot of creativity here, but they should bear in mind that the scenarios are plausible and internally consistent.
Test the scenarios. In a next step, the scenarios should be tested on their internal consistency. Tests for internal consistency are quantification of scenarios and analysis of actor behaviour within the scenarios. The different scenarios can be used to confront the organisational strategy with. This will lead to insight into possible discrepancies between the strategy and projected environmental developments. These discrepancies can form the basis for adjustment of the objectives or new objectives. Some principles which should be borne in mind when scenarios are developed are (Van der Heijden, 1996):

- At least two scenarios are necessary to reflect uncertainty. More than four scenarios are difficult to work with.
- The scenarios must be plausible, which implies that they must grow logically from the past and the present.
- The scenarios must be internally consistent. Events should be related through cause and effects lines which cannot be flawed.
- The scenarios must be useful and challenging idea generators and test conditions, against which future business plans and strategies can be tested.
- Events which are bound to happen with certainty should appear in every scenario.

Who
Building good scenarios requires considerable effort. When organisations are seriously engaged in scenario planning, a separate multi disciplinary scenario team is necessary. In principle, scenarios can be made at all levels of the organisation.

Inputs
To build scenarios, information on past and current events is necessary. This can be obtained through market research, history surveys and interviewing key persons in the organisation. In order to obtain additional information and give comments on the deduced patterns, Van der Heijden (1996) suggests to consult ‘remarkable’ people. These can be artists, opinion leaders, experts, etc.

Outputs
Scenario planning should result in at least two different scenarios of the future.
Theoretical support
Scenario planning finds support in theory on strategy development and theory on uncertainty reduction and risk management. Theory on scenario planning itself is for a large part derived from practical experience.

Combination possibilities
Scenarios form a basis against which strategy developments can be projected. As such scenario planning can be combined with methods supporting strategy development. Scenario planning itself makes use of many other support methods, such as the five forces framework, SWOT analysis, diagramming techniques, brainstorming, etc.

Use in practice and (dis)advantages
In the business world, the Shell corporation is a large champion of scenario planning. The CPB Netherlands Bureau for Economic Policy Analysis is an organisation which publishes scenarios on the development of the Dutch economy at a macro-economic level. An advantage of scenarios is that they offer a broader picture of the future than a single forecast and give insight into structural uncertainties. Organisations should be aware that development of good scenarios is time consuming and laborious. Decision-makers should have the skills to systematically combine thorough analysis with creativity (Robson, 1997).

5.2.7 Balanced scorecard method

What
The balanced scorecard (BSC) is a performance measurement method consisting of a set of measures that gives top managers a quick but sweeping view of the business. Within the decision-making process, the BSC is relevant in the objective setting stage. It provides a broader view on objectives and the organisation than just the financial perspective. BSC can be used to structure the objectives, the decision criteria and the underlying effects. Kaplan and Norton developed the BSC as a performance measurement system in order to implement and manage the organisation's strategy (1992, 1993, 1996a, 1996b). The complexity of an organisation today requires that managers are able to view performance in several areas simultaneously. BSC forces managers to focus on the measures that are most critical and introduces four perspectives for the measurement of organisational performance. Because the BSC requires the managers to select a number of critical indicators within each of the four perspectives, the scorecard helps to focus the strategic vision. The four perspectives within BSC are (see also Figure 5.4):
- The financial perspective, which gives insight into the ultimate financial result of the operational business. Objectives typically relate to profitability, growth and return, measured, for example by operating income, return-on-capital-employed and economic value-added. Alternative financial objectives can be rapid sales growth or generation of cash flow (Kaplan and Norton, 1996b).

- The customer perspective, which relates to the valuation by customers of the service of the organisation. Kaplan and Norton (1996b) define for this group the following core outcome measures: customer satisfaction, customer retention, new customer acquisition, customer profitability, and market and account share in the targeted segments.

- The internal business process perspective, which measures the performance of the most important business processes or ‘core competencies’. These are the processes in which the organisation should excel while they will have the greatest impact on customer satisfaction and achieving the organisation’s financial objectives. The speed, quality, reliability and costs of these critical business processes, as well as new product introductions are the most important measures for judgement.

- The learning and growth perspective, which sheds light on the developments leading to the realisation of customer and process objectives and eventually the financial objectives. This perspective identifies the infrastructure that the organisation must build to create long-term growth and improvement. Learning and growth come from three sources: people, systems and organisational procedures. Measures are related to speed and success of product development activities, human satisfaction, human productivity and loyalty, as well as to availability of (strategic) information systems and changes in organisational routines and procedures.

The scorecard should managers guard for sub-optimisation. It forces managers to consider all important measures together. This makes it possible to see whether improvement in one area occurred at the expense of other areas. Note that the perspectives are not orthogonal, they are hierarchically related, in which attaining the financial objective is the top goal.
The emphasis many organisations place on short-term financial measures leaves a gap between the development of a strategy and its implementation (Kaplan and Norton, 1996a). The BSC is intended for learning instead of just monitoring and tries to link the long-term strategies with short-term actions by introducing four new management processes (see for an extensive description Kaplan and Norton, 1996b).

- **Translating the vision**, consisting of clarifying the vision and gaining consensus. This process helps managers create consensus around the organisation’s vision and strategy.
- **Communicating and linking**, consisting of communicating and educating, setting goals and linking rewards to performance measures.
- **Business planning**, consisting of setting targets, aligning strategic initiatives, allocating resources and establishing milestones.
- **Feedback and learning**, consisting of articulating the shared vision, supplying strategic feedback and facilitating strategy review and learning.
How
Every organisation should specify a BSC according its own specific situation. Successful implementation demands a good selection of perspectives and measures and a careful introduction. It is demanding towards the organisational information provision and requires a stable strategy. Creating a BSC forces organisations to integrate their strategic planning and budgeting process and therefore helps to ensure that the budgets support the strategies. It may also be used as a framework for managing the organisation’s change programs. To support the use of the BSC, Kaplan and Norton argue that information systems are invaluable. On the one hand information systems can help to decompose summary measures of the BSC. On the other hand they can supply timely management information to fill in the BSC measurement values.

Who
Active involvement of top management in building a BSC is necessary. Building a BSC is laborious and requires much effort. A special task force may be appropriate for the development.

Inputs
From a customer’s perspective four categories of measures are important (Kaplan and Norton, 1992): time, quality, performance and service, and cost. In order to let the BSC work, organisations should determine objectives for these categories and then translate them into specific measures. Customer-based measures need to be translated into measures of what the company needs to do internally to meet its customers’ expectations. Managers therefore need to focus on those critical internal operations that enable the organisation to satisfy customer needs. While the operations in the organisations generally occur at department levels, the overall measures for cycle time, quality, product and cost need to be decomposed to the level of the sub-units. Financial performance measures indicate whether the organisation’s strategy and the strategy implementation and execution contribute to bottom-line improvement (Kaplan and Norton, 1992). Financial objectives are usually related to profitability, growth and shareholder value. Kaplan and Norton provide two reasons why financial measures are necessary. They state that a well-designed financial control system will enhance rather than inhibit an organisation’s total quality management program. The second reason is that the alleged linkage between improved operating performance and financial success is actually quite tenuous and uncertain. If improved performance fails to be reflected in the bottom line, executives should re-examine the basic assumptions of their strategy and mission. The organisation’s ability to innovate, improve and learn is directly related to the value of the
organisation for its shareholders. Shareholder value is included in the BSC as a performance indicator, although this measure is a result and not a driver of performance. Kaplan and Norton included this measure in the BSC to offset the emphasis on gross margin and sales growth. These latter measures ignore the investments today to generate growth of tomorrow (which is one of the problems recognised for telematics infrastructure investments).

**Outputs**
The BSC gives insight into the performance of the organisation on broad range of criteria. This can be a starting point to strengthen the position on certain criteria or improve the performance on others.

**Theoretical support**
The BSC is developed in consultancy practice. It does, however, make use of theory on capital budgeting, strategy development and organisational (or process) alignment.

**Combination possibilities**
The method itself combines both financial and non-financial aspects of the organisation and its activities. The method is comprehensive and can be used in objective setting and alternatives assessment. As such, it should be combined with a method to generate alternatives.

**Use in practice and (dis)advantages**
The BSC evolved in the nineties and is currently in use by several (large) organisations. Development of the approach took place in close association with organisations representing different sectors. Advantage of the method is that it is quite comprehensive. Another advantage is that it can be used in the objective setting stage, as well as in the alternative assessment stage. It is also a useful method to evaluate implemented projects on their performance. Yet, organisations should be aware that developing a BSC costs a considerable amount of time: a BSC could be developed within 16 weeks but can take up six months (Kaplan and Norton, 1996b).

**5.2.8 Venkatraman’s BPR framework**

**What**
Venkatraman developed a five-level framework of IT-enabled business transformation which can be used as an IT investment classification in terms of business impact (Figure 5.5). The five levels do not correspond to stages of evolution, but are distinct levels of business reconfigurations with an explicit focus on the role of IT (Venkatraman, 1991). The first and
second level mainly require *incremental* changes. At the three highest levels investments influencing the organisational *structure* are executed.

Figure 5.5 indicates that the higher the level of change, the higher the range of potential benefits will be. The different levels can be seen as follows (Venkatraman, 1991, 1994).

1. At the *localised exploitation* level, IT is exploited within existing isolated business activities, normally within one function. Applications are deployed to improve task efficiency of operations without necessarily influencing related areas of operations. Sometimes effectiveness improvements are achieved.

2. Investments at the *internal integration* level are aimed at building the internal electronic infrastructure or platform. The major objective is to elevate IT as a strategic resource. Technical integration is necessary, which implies the integration of the different systems and applications. Also organisational integration is necessary, which implies the integration of different roles and responsibilities that exploits the technical integration capabilities.

3. The *business process redesign* level comprises a rethinking of the most effective way to conduct business, by using IT as a lever. Instead of treating the business process as a constraint in IT deployment, the business process itself is redesigned to exploit the available IT capabilities. There should be an alignment between the IT infrastructure and the business process.

4. At the *business network redesign* level, the organisation uses IT to include suppliers, customers, or anyone else who contributes to the organisation’s effectiveness. The organisation moves from the traditional formal organisation to a ‘virtual’ or ‘networked’ organisation that works together to accomplish a certain purpose. A reconfiguration of the scope
and tasks of the business network involved in the creation and delivery of products should take place. This includes the business tasks both within and outside formal boundaries of a focal organisation and the consequent redesign of the virtual network.

5. At the business scope redefinition level an organisation changes its traditional way of working and exploit new IT in the marketplace or in products. The major objective is to identify new business as well as potential threats. Activities at this level pertain to the possibilities of pro-actively and reactively enlarging the business mission and scope (through related products) as well as shifting the business scope (through the substitution of traditional capabilities with IT-enabled skills).

How
The framework classifies the investments according to their organisational scope and type of change it facilitates. This change can be in terms of integrating processes or restructuring processes. This implies that decision-makers should determine where the investment will or has to impact and what the investment actually establishes.

Who
The framework is particularly useful for top management which has to decide where to focus upon and how to divide investment budgets.

Inputs
For a classification of telematics investments, the investment proposals themselves are necessary. In order to classify the investments the decision-makers should already have an indication of the objectives, because these will for a part determine where the investment should be applied. As such, the framework can be used to clarify the relation between the objectives and the proposed investments and is an addition to objective setting. Next to that, decision-makers should have sufficient information on the business processes, both within the organisation and within the network in which the organisation is active.

Outputs
The output of this exercise will be a classification of the telematics investments according to the location and scope of their impact. This may be of use in finding the effects of the investment, which on their turn can be used as input for the assessment stage of the decision process.

Theoretical support
In the first half of the nineties considerable attention has been given to the concepts and application of Business Process Redesign/Re-engineering,
Combination possibilities
The framework in itself is insufficient to support objective setting. It can be used as an addition to other methods.

Use in practice and (dis)advantages
Despite its popularity in both the academic press and business press, it is unclear whether the method was or is used in practice. A possible disadvantage of the framework is the suggested emphasis on restructuring, which is not always the intention of telematics investments. A focus on constant change may scare away decision-makers. An advantage of the framework is that its scope surpasses the organisational boundaries, forcing the decision-makers to have a broader view on their organisation. This is particularly useful for telematics investments while they often cross organisational boundaries (see chapter 1).

5.3 Methods to support alternatives generation

In Table 5.5 we gathered several methods which can be of use for the generation of alternatives.

Table 5.5 Methods for alternatives generation

<table>
<thead>
<tr>
<th>Methods for alternatives generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstorming/group sessions on idea making</td>
</tr>
<tr>
<td>Strategic options generator (Wiseman, 1994)</td>
</tr>
<tr>
<td>Scenario planning (Schoemaker, 1995; Van der Heijden, 1996)</td>
</tr>
<tr>
<td>Example situations (Ijpeelaar, 1993; Teeuw et al. 1994)</td>
</tr>
</tbody>
</table>

5.3.1 Brainstorming

What
Perhaps the most commonly used approach towards generation of ideas is brainstorming: generation of ideas on a certain subject by a group of persons.

How
A group comes together to freely generate ideas on a certain topic, for example by associating and reacting to what other members in the group come up with. It is important that all ideas are initially accepted, how odd they may seem. The process can be performed in iterative sessions, where group members associate new topics with the ones generated in the previous stage. A moderator can attend and chair the session, in order to
structure the process. Structuring can also be done by organising the brainstorm in the form of a meta-plan session. Another advanced form of brainstorming is the use of Group Decision Support systems. These IT systems (mostly linked PCs) save all ideas and make it possible to anonymously react on ideas of others. This latter feature may be useful for groups with very divergent ideas or where tight hierarchical relations exist or where a certain amount of hostility exist.

Who
Nearly every group within the organisation can perform brainstorming sessions. When it comes to brainstorming on alternatives for telematics investments, it is useful to construct a (multi disciplinary) group consisting of users, decision-makers and telematics experts.

Inputs
Inputs of the session should be the organisational objectives and the ideas of the people involved.

Outputs
Output of the session should be a set of alternatives.

Theoretical support
Support for brainstorming can be found in literature on group decision-making and group or organisational behaviour.

Combination possibilities
While decision-making is a very general method, it can be combined with many other methods. In that sense, it is useful as a first approach to generate ideas on a particular topic, after which other approaches can be used to detail out the alternatives generated.

Use in practice and (dis)advantages
The method is widely used in practice in nearly all sorts of organisations. An clear advantage is its ease of use. However, organisations should be aware that its ease of use should not lead to a lack of commitment.

5.3.2 Strategic option generator

What
The strategic option generator (Wiseman, 1985) is an extension of the work of Porter on competitive strategy and provides a framework to generate strategic opportunities.
How
The following steps should be taken.
1. Determine the strategic target (supplier; customer; competitor).
2. Determine the strategy to follow (differentiation; low costs, innovation; growth; co-operation). An organisation should determine its strategic thrusts: major moves which can be offensive and defensive. The method suggests that all activities can be categorised under these thrusts.
3. Determine the strategic character (an offensive or defensive approach)
4. Determine the strategic use (internally or externally)

Every combination of factors is a possible source (offers options) for the identification of strategic information systems (which should be determined by brainstorming!). Its use is mainly aimed at the environment of the organisation and less at the internal business processes. The option generator is a grid on which target groups and thrusts can be positioned. We depicted this in Table 5.6.

<table>
<thead>
<tr>
<th>Strategic target →</th>
<th>Supplier</th>
<th>Customer</th>
<th>Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic thrust ↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differentiation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.6 The strategic option generator

Who
Management should use the strategic option generator.

Inputs
Information on the target groups and information on the strategy to follow or the objectives to be fulfilled.

Outputs
The activities should result in a strategic option generator, as depicted in Table 5.6, with the cells filled in.

Theoretical support
The strategic option generator is based on concepts from the theory of competitive strategy.

Combination possibilities
The generator is a mechanism to combine strategies with target groups. As such, it can be used to select a combination on which the decision-makers
will work further. It is not sufficient as a base for concrete investment decisions.

**Use in practice and (dis)advantages**
It is unclear whether the option generator is in use in practice. It can facilitate the distinction in different strategies for different groups. A possible advantage is that it may quickly offer insight into combinations of target groups and strategies to follow.

**5.3.3 Scenario planning**

**What**
Scenario planning is not only useful to test the business objectives against, it can also serve as a basis for alternatives generation.

**How**
We already have given a short description of scenario development in section 5.2. Decision-makers should imagine that each of the scenarios have come true and then find out what the organisation should or can do given that scenario. Such discussions can follow three levels in turn (Van der Heijden, 1996):

- **The societal level.** At this level, the organisation address the question of what the world at large, and the organisation’s stakeholders in particular, will need in the specific scenario.

- **The strategic implications level.** Decision-makers should at this level try to determine the implications for the organisation of the identified opportunities at societal level.

- **The (strategic) options level.** On the basis of the confrontation between the opportunities and organisational strategy, options can be derived. Van der Heijden recognises two types: options which can readily be exploited and options for further extension of competitive advantage.

**Who**
The developed scenarios can be used in management discussions on potential possibilities for the organisation.

**Inputs**
When the scenarios are already developed in the objective setting stage, they will form the input, together with the organisational objectives.

**Outputs**
The session should result in a set of options (alternatives).
**Theoretical support**

Scenario planning finds support in theory on strategy development and theory on uncertainty reduction and risk management. Theory on scenario planning itself is for a large part derived from practical experience. Further support can be found in literature on group decision-making and group or organisational behaviour.

**Combination possibilities**

The use of scenarios for alternatives generation is a logical extension of their use in the objective setting stage. It can be combined with brainstorming sessions.

**Use in practice and (dis)advantages**

Whether organisations in practice make use of scenarios for alternatives generation is unclear. Decision-makers should carefully consider whether they want to develop scenarios solely for the generation of alternatives, while the development requires serious effort. An advantage of using scenarios is that decision-makers look further in the future than the planning horizon, thus making them think about future investments opportunities which can follow the investment opportunities at hand.

### 5.3.4 Example situations

**What**

An approach to support alternatives generation which is very simple in use, is the provision of example situations.

**How**

Decision-makers simply take a look at lists of examples of the application of telematics in certain situations. Organisations which lack experience in generating alternatives may find examples useful. They should be aware that situations as described by examples normally cannot be copied to their own situation. Adjustments have to be made and investment proposals have to be specified according to the organisational use.

Examples may come from research. For example, Ijpeelaar (1993) gives several lists of situations, IT possibilities and combinations of the two. Another source of examples is formed by descriptions of (successful) projects in which telematics is introduced. Teeuw et al. (1994), for example, give an overview and a technical and organisational analysis of projects in which Product Data Interchange was introduced. Such overviews are available for many sorts of projects.
Who
The group which prepares investment proposals or is responsible for generating alternatives should make use of the example situations.

Inputs
Inputs are formed by existing developed lists of example situations or by summaries of successful projects (for example, the descriptions of the EDI projects in the book “EDI in Europe”, see chapter 4).

Outputs
The use of example situations should result in a list of comparable situations to the situation which the organisation wants to alter. The examples must show what the results of the investment were.

Theoretical support
In organisational theory, strategy development and management literature, a common approach is to present cases which describe developments and investments and their consequences. These cases are usually aimed at communicating and sharing best practices and lessons learned or at providing material against which an organisation can benchmark itself.

Combination possibilities
Examples can be used with nearly all other support methods. They can form a basis or input for further development of alternatives.

Use in practice and (dis)advantages
Many organisations implicitly or explicitly make use of examples, often for benchmarking purposes. Advantage of examples is that they show how things should or should not be done. A disadvantage of this approach is its reactive character and the danger of copying investment projects that do not exactly fit the setting of the organisation itself. Moreover, the lists should be updated regularly, because the business, the environment and the technology constantly change.

5.4 Methods to support alternatives assessment

When an organisation wants to invest in new technology, it should be aware of the effects in terms of costs and benefits, complexity and the way they can be combined with existing activities (Wissema and Euser, 1988). An organisation has to assess alternatives on their merits. Methods to support alternatives assessment are frequently discussed in literature. Many methods for this stage have been developed. Bruggeman (1996) distinguishes five
types of methods by which an IT-investment can be supported or evaluated: financial methods; multi-criteria methods; portfolio methods; ratio methods and the option method. We will use this classification as well, see Table 5.7. In their work, Berghout and Renkema (1994) already recognised 61 methods to support investment decisions. Renkema (1996) also offers a very large list of existing methods to support investment decisions, of which most aim at support for assessment. They, however, do not claim to be exhaustive and expect that further developments will undoubtedly lead to new methods. Here, we also refrain from giving an exhaustive analysis. For each type of method we will present one or two examples.

<table>
<thead>
<tr>
<th>Financial methods:</th>
<th>Payback period, NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-criteria methods:</td>
<td>Information Economics (Parker et al. 1988), Kohler Unit Framework (Hochstrasser, 1994)</td>
</tr>
<tr>
<td>Portfolio methods:</td>
<td>Method of Bedell (1985)</td>
</tr>
<tr>
<td>Ratio methods:</td>
<td>Return On Management (Strassmann, 1990)</td>
</tr>
<tr>
<td>Option methods</td>
<td>Framework of Luehrman (1998a,b)</td>
</tr>
</tbody>
</table>

5.4.1 Financial methods

Two frequently used financial methods are presented here: the payback period and the Net Present Value.

**Payback period - What**

Payback period is a formal, structured, financial method to determine the payback period of investment alternatives.

**How**

Decision-makers should first determine at what point in time the net cash outlays are compensated by the net cash revenues. Then, select an alternative or, if only one alternative is assessed, accept or reject the alternative if it falls before or after the target which may have been set. Decision-makers should choose the alternative with shortest payback period or choose the alternatives with payback periods which fall in the targeted payback period.

**Who**

The method should be used by the decision-makers or the group which prepares investment proposals.

**Inputs**

Estimated cash outlays and cash revenues, estimated life cycle of the alternatives and possible target payback period.
Outputs
The method should result in a ranking of the alternatives on the basis of their estimated payback period.

Theoretical support
The method is usually described in welfare economics and capital budgeting literature (see for example Pearce, 1983; Bierman and Smidt, 1993). It is appreciated for its ease of use, but simple payback period is rejected because it is inferior to methods which take the time value of money into account.

Combination possibilities
In literature it is suggested that the method should never be used as a single decision method. It should be used in combination with other financial methods (like the Net Present Value) or with non-financial methods.

Use in practice and (dis)advantages
Almost all types of organisations make use of this method, clearly because of its advantage: it is extremely easy to use. Yet, the method has several serious disadvantages. It focuses on short term results and stops taking into account the cash outlays and revenues which take place after the payback moment. This makes it unsuitable for a comparison of investments with wholly different flows of costs and benefits. Furthermore, payback period only takes the quantitative, financial aspect of alternatives into account, while many other criteria will also play a role. Besides, simple payback period does not take account of the time value of money. A practical problem is the proper estimation of the cash outlays and revenues and determination of the life cycle of the investment alternatives. A mistake which is often made in practice is the use of the payback period as a single criterion to base a decision on, which offers insufficient grip for decision-makers.

Net Present Value - What
Net Present Value (NPV) is a formal, structured, financial method to determine the net present value of investment alternatives. It is the sum of the present values of all future net cash flows, minus the initial cash outlay. Bierman and Smidt (1993) define it as: “With zero taxes, the net present value of an investment may be described as the maximum amount a firm could pay for the opportunity of making the investment without being financially worse off.”

How
The approach is to fill in the NPV formula with the inputs and calculate the discounted cash flow:
Net present value formula

\[ NPV = -C_0 + \sum_{i=1}^{T} \frac{A_t}{(1 + r)^t} \]

Where
- \( C_0 \) = investment at the start of the project (i.e., \( t = 0 \))
- \( A_t \) = cash flow at the end of period \( t \)
- \( T \) = project life
- \( r \) = risk-based discount rate for the project determined by finding the rate of return provided by a market-traded investment with similar risk.

The approach when alternatives are mutually exclusive (investments that adversely affect the earning possibilities of each other (Bierman and Smidt, 1993)) is to rank them by their NPV and choose the one with the highest NPV. For a single alternative: accept it if \( NPV \geq 0 \) and it fits within the budget.

When budget constraints are in place and the alternatives are not mutually exclusive, mixed integer programming is needed to find the best alternative.

**Who**
The method should be used by the decision-makers or the group which prepares investment proposals.

**Inputs**
Estimated cash outlays and cash revenues, estimated life cycle of the alternatives, estimated discount rate.

**Outputs**
Output of the NPV is a ranking of projects on the basis of their NPV. Reliability for non-routine (such as strategic telematics) investments is difficult to determine. The time span of the prediction depends on the estimation of the life cycle of the investment alternative.

**Theoretical support**
The method is grounded in welfare economics and capital budgeting (see for example Pearce, 1983; Bierman and Smidt, 1993). Use of NPV is recommended over the simple financial methods because of its comprehensiveness.

**Combination possibilities**
Especially for the adjustment of the discount rate to risk, various methods are recommended, such as simulation, sensitivity analysis, use of hurdle rates etc. NPV is also often the basic criterion within an assessment and
then supplemented by other criteria which give an indication of non-
financial issues of the alternatives (see the Information Economics approach
in section 5.4.2).

**Use in practice and (dis)advantages**
The method is often used in practice, mainly by large organisations.
Advantages of NPV are that it measures what it should measure, its ease of
use, it is commonly accepted and it generates clear results which makes
communication about alternatives easier. A disadvantage is that NPV only
takes the quantitative, financial aspect of alternatives into account, while
many other criteria will also play a role. Furthermore, in practice it is hard
to determine an appropriate discount rate (Dos Santos, 1991), to estimate
the cash outlays and revenues and to determine the life cycle of the
investment alternatives.

5.4.2 Multi-criteria methods
In this section we present two multi-criteria methods which are developed
to support decision-making on IT investments. First, the Information
Economics approach of Parker et al. (1988) is presented and then the
Kobler Unit framework (Hochstrasser, 1994). The methods cover more
stages of the decision process than just the assessment of alternatives, but
their focus is specifically aimed at assessment. We therefore classified them
in this group.

**Information Economics - What**
Information Economics (IE) tries to structure group decision-making. As
such, it is intended to cover all steps in the decision making process, but its
major emphasis is put on the assessment stage. The method compares
various investment alternatives (which can be derived by answering the 7-
questions list as proposed by Parker et al. 1988), on the basis of weighed
criteria. Its focus is on value added instead of cost savings. The method is
intended for alternatives assessment and is IT-specific. For extensive
descriptions we refer to Parker et al. 1988; Sebus, 1991; Delahaye and Van
Reeken, 1992; Oosterhaven, 1992; Oirsouw et al. 1993; Berghout and

**How**
The method uses a common multi-criteria approach, known as weighted
summation: determine the values of the criteria for the different
alternatives, give them a score (e.g. from 0 - 5), determine the weights of
the criteria, multiply the scores with the weights and add them together.
The result can be used to rank the alternatives.
Who
The method can be executed by management, supported by an expert. The approach can be performed in the form of a workshop.

Inputs
IE uses ten decision criteria. The first one is a quantitative financial criterion: enhanced return on investment. The enhancement is obtained by adding to simple return on investments the value obtained by value linking, value acceleration, value restructuring, and innovation valuation (see for a description Parker et al. 1988). The qualitative criteria are competitive advantage, strategic match, competitive response, strategic IS architecture, management information (other criteria are possible). Next to these, there are four risk criteria: project or organisational risk, IS infrastructure risk, technical uncertainty and definitional uncertainty.

The decision-makers should gather information on all these criteria and they have to determine weights which can be assigned to these criteria.

Outputs
In the assessment stage, the alternatives are ranked. This ranking can be the basis for a choice. Interpretation of the values of the final figures is usually difficult because they are synthetic. Decision-makers should note that the approach is intended to compare results of the different alternatives, the method gives not the absolute value of the results.

Theoretical support
Theory on ‘value’ and ‘worth’ and theory on the alignment of the business domain and the IT-domain. The approach gained much attention and popularity in the eighties and early nineties and served as a basis for many approaches towards IT-assessment.

Combination possibilities
Combination possibilities are not mentioned. The method itself is rather comprehensive and covers may aspects in the assessment of alternatives by using several different approaches.

Use in practice and (dis)advantages
Several large organisations use the method. Some organisations adjusted the criteria to their own situation and needs. Many other organisations became aware of the use of multiple criteria in decision-making instead of a single financial criterion. A clear advantage of the method is that it uses quantitative and qualitative criteria and is made IT-specific. Besides, its purpose is to support group decision-making. Wiseman (1994) mentioned seven C’s of IE: comprehensiveness, consistency, clarity, communications,
confidence, consensus, culture. These C’s can be seen as advantages and may be attained by properly applying IE within the decision process.

The problem of estimating of the cash outlays and revenues and determination of the life cycle of the investment alternatives for the financial part of the method remains. Another problem is the subjective assigning of scores and weights to criteria, which makes the reconstruction and validation of the results difficult.

**Kobler Unit Framework - What**

The Kobler Unit Framework consists of four modules for justifying IT investment that concentrate on critical success factors, risk assessment, business performance indicators and on strategic alignment (Hochstrasser, 1994; Whiting et al. 1996). The method is intended for both alternatives and organisation assessment and is IT-specific (intended for non-infrastructure IT investments).

The method can also be used in objective setting where objectives have to be made operational and measurable. Module 3 of the method, in which business performance indicators are determined, can be used for this purpose.

**How**

Decision-makers have to sequentially carry out the four modules, which all contain questions and indicators which must be filled out. With the first module, the decision-makers set the organisational context and then compares various alternatives on the basis of weighed criteria.

**Who**

The method is intended for the strategic management group, which should comprise IT professionals, business managers and users.

**Inputs**

The inputs are:
- For module 1, corporate standards for new IT initiatives: a set of critical success factors.
- For module 2, awareness of potential wider effects: estimates of the true costs of the IT-project (both direct and indirect costs).
- For module 3, business performance indicators: specified measurable business metrics and estimates of values for these metrics, depending on the (overlapping) project types (internal, external, cost replacement, economy of scale, economy of scope, customer support, quality support, information sharing and manipulation, and new technology projects).
- For module 4, project priority value: inputs from the other modules.
Outputs
Project priority values form the output of this framework. In the choice stage, decision-makers should choose the project with the highest project priority value. Reliability is unclear, yet advice is given to regular re-evaluate during the course of the project.

Theoretical support
Theoretical support is partly found in capital budgeting theory and partly in theory on the alignment of the business domain and the IT-domain.

Combination possibilities
The method itself already contains other methods, such as the CSF approach.

Use in practice and (dis)advantages
Its use in practice is unclear, it is a proposed framework. While this remains unclear, we can only present expected advantages and disadvantages. An advantage is that the method uses both quantitative and qualitative criteria based on demand from industry and is made IT-specific. Another advantage is its aim to support group decision-making. Furthermore, it explicitly emphasises the re-evaluation of the results during the course of the project. A disadvantage is the subjective assigning of scores and weights to criteria, which makes the reconstruction and validation of the results difficult. Besides, decision-makers must determine the success factors and business performance indicators, based on a (subjective) classification of the project. Furthermore, the method uses many criteria, which makes it laborious to work with.

5.4.3 Portfolio methods
General goal of portfolio methods is to create and balance portfolios of projects which are most interesting (in financial terms) for the organisation. Often, these methods make use of matrices in which the proposed projects are compared with each other. The axes of the matrix can contain various indicators, which makes it possible to simultaneously compare the projects on two dimensions. An obvious limitation is that a matrix only has two dimensions and the danger of subjective placement of projects within the matrix also exists. As an example we present the method of Bedell (1985). For further elaboration on these methods see also Delahaye and Van Reeken (1992); Berghout and Renkema (1994); Renkema (1996).
Bedell's method - What
Bedell's method tries to find productive applications by first closely scrutinising the current information systems and then prioritising the proposed applications on the basis of their importance to the organisation and the quality of existing systems. The alternatives are projected in matrices (portfolio's) and then compared. The method assesses both the organisation and IT-alternatives; it is IT-specific.

The method cannot only be used in alternatives assessment. By determining the difference between the current and potential effect of the current information systems, the method stimulates thinking of the direction in which alternatives should be sought. Hence, it can also be used for alternatives generation.

How
The decision-makers should answer the following set of questions:
- Which effects do current information systems have on the organisation?
- Which effects could the current information systems have?
- Should the organisation invest in IT applications?
- For which activities should IT applications be developed?
- Which IT applications should be developed?

Priorities between alternatives are established by determining their contribution: the importance of the system multiplied by the improvement in quality after the development of the application. If this does not lead to a dominant alternative, a project-profitability index can be determined by dividing the contribution of the alternative by the outlays.

Who
The method is intended to support management, the IS department and users.

Inputs
Inputs are estimations of importance of activities for the organisation, importance of information functions for the activities and quality (determined by efficiency, effectiveness and timing) of existing systems.

Outputs
Outputs are listed alternatives contributions and/or the project profitability index. Decision-makers should choose the alternative with the highest contribution or the highest project-profitability index. The reliability of the results is unclear.

Theoretical support
The method is based in theory on (IT) strategy development.
Combination possibilities
Combination possibilities with other methods are not mentioned.

Use in practice and (dis)advantages
The method is hardly in use in practice. Advantages of the method are that a comparison of current effects of information systems with potential effects is made and that through use of matrices the differences between projects are easily made visible. Another advantage is that the method first seeks an answer to the question if investments in current information systems are necessary or that the priority for those investments is not high enough. A disadvantage for use in practice is the method's complexity of use. A danger exists that decision-makers will be scared away, because the method is laborious to work with.

5.4.4 Ratio methods
Ratio methods assess alternatives on the basis of the relation between criteria. The resulting ratio score for an alternative can be used to compare with target values or benchmarks. A ratio method which obtained much attention is Return On Management, which is presented below.

Return On Management - What
Return On Management (ROM) compares the management value added with a benchmark (the commercial MPIT database with data on 300 organisations). The benchmark can be used for an overall screening of the organisation and for the analysis of the expected effects of specific interventions. The method is intended for organisation assessment and is not telematics-specific. The method is developed by Strassmann (1990). Further explanation can also be found in Berghout and Renkema (1994); Renkema (1996).

How
The method relates the management value added to the costs of management. The ‘formula’ is as follows:

\[
ROM = \frac{\text{revenue} - \text{full operations cost}}{\text{costs} - \text{full operations cost}} = \frac{\text{value added by management}}{\text{full cost of management}} = 1 + \frac{\text{economic profit before taxes}}{\text{full cost of management}}
\]

Who
No suggestion is given on who should use the method (given the fact that management is evaluated, it might be possible that the method is useful for various stakeholders).
Inputs
The inputs for the method are:
- Management value added = revenue - purchases - shareholder value added - operation costs - management costs.
- Costs of management.

Outputs
The output is ROM as a percentage, classified in five intervals, ranging from under achievers to over achievers.

Theoretical support
The method is grounded in basic economic theory on the division of scarce resources (management as a scarce resource).

Combination possibilities
No suggestion for combinations is given. Bruggeman (1996) argues that ratio methods in general cannot be practically used for the justification of investment proposals. They might be used as test instrument, next to other methods.

Use in practice and (dis)advantages
Use in practice of ROM is unclear, however, the MPII database is commercially exploited, which may be an indicator that the ROM benchmark is actually used. An advantage of the method is the ease of calculation of the formula. A disadvantage is that ROM has no relation with more common (financial) criteria. Another disadvantage is that the data which serve as the basis for the benchmark are not public and probably stem from American companies, which might bias the values of the benchmark.

5.4.5 Option theory
In order to improve assessment of IT-investments by financial criteria, in particular those in IT-infrastructure, Dos Santos (1991) developed the option theory approach. Currently, several authors have shed light on the application of option theory in the practice of decision-making (Allas et al. 1996; Leslie and Michaels, 1997; Copeland and Keenan, 1998a,b), whereas Luehrman developed a framework for the application of the theory to ‘real’ options (1998a,b).

What
Real option valuation is intended for assessment of (consecutive) projects and was IT-specific (intended for IT infrastructure and strategic
investments), but can also be applied to other investment decisions. Option theory tries to find an answer to the question 'is investment in the new technology justified?' (Dos Santos, 1991). The option theory approach is being developed as an alternative for/addition to traditional capital-budgeting methods which are difficult to apply to (IT) infrastructure investments and investments that are strategic in nature. Using the NPV to assess the value of these so-called first stage projects will usually turn out in a rejection of them, because the benefits are too small to justify the investment. Another serious problem with the NPV approach is that it does not consider the flexibility that the firm has in managing the assimilation of a new technology. Option theory suggests that investment in a first-stage project provides management with a number of options in dealing with the second-stage projects. By investing in IT, the organisation acquires options to invest in new project with the means which accrue from the first investment (also the option not to invest).

Real option valuation is important in situations of high uncertainty. Theory of real options considers two forms of uncertainty: uncertainty about the future and uncertainty on the ability of management to respond to what it learns as the future becomes brighter (Copeland and Keenan, 1998a). A method to deal with uncertainty about the future is to postpone decisions. Postponement is waiting with operations until exact customer requirements can be specified (CLM, 1995). Option pricing also presumes that decisions can be deferred. The difference with the above postponement is that option theory discusses investment decisions. Deferral of investment decisions leads to two additional sources of value:

- the time value of money on the deferred expenditure
- the value derived from changing circumstances

Option theory is an approach for quantifying these two additional sources of value.

**How**

Within the option theory approach, a distinction is made between first stage (infrastructure) projects and second stage projects. The approach recognises that the potential value of future projects account for a major portion of the value of the initial project and hence, that this future value should be taken into account when justifying first stage projects.

Luehrman (1998a and 1998b) presents a framework which makes it possible to use option theory concepts in the valuation of investment opportunities as a complement to discounted cash flow analysis.

The relation between the variables of an investment alternative and the variables determining a European call option are given in Table 5.8.
Table 5.8 Mapping an investment opportunity onto a European call option (Luehrman, 1998a)

<table>
<thead>
<tr>
<th>Investment opportunity</th>
<th>Call option</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present value of a project’s operating assets to be acquired</td>
<td>Stock price</td>
<td>( S )</td>
</tr>
<tr>
<td>Expenditure required to acquire the project assets</td>
<td>Exercise price</td>
<td>( X )</td>
</tr>
<tr>
<td>Length of time the decision may be deferred</td>
<td>Time to expiration</td>
<td>( t )</td>
</tr>
<tr>
<td>Time value of money</td>
<td>Risk-free rate of return</td>
<td>( r_f )</td>
</tr>
<tr>
<td>Riskiness of the project assets</td>
<td>Variance of returns on stock</td>
<td>( \sigma )</td>
</tr>
</tbody>
</table>

The amount of money expended corresponds to the option’s exercise price \( (X) \). The present value of the asset acquired corresponds to the stock price \( (S) \). The length of time an organisation can defer the investment decision without losing the opportunity corresponds to the option’s time to expiration \( (t) \). The uncertainty about the future value of the project’s cash flows (i.e. the amount of risk associated with the project) corresponds to the variance of returns on the stock \( (\sigma) \). The time value of money in both cases is given by the risk-free rate of return \( (r_f) \).

A project’s options value and NPV are the same when a final decision on the project cannot longer be deferred, see also Table 5.9.

<table>
<thead>
<tr>
<th>Conventional NPV</th>
<th>Option value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{NPV} = \text{(value of project assets) - (expenditure required)} )</td>
<td>When ( t=0, \sigma^2 ), and ( r_f ) do not affect call option value</td>
</tr>
<tr>
<td>( \uparrow ) This is ( S )</td>
<td>( \uparrow ) This is ( X )</td>
</tr>
<tr>
<td>( \downarrow )</td>
<td>At expiration, call option value is</td>
</tr>
<tr>
<td>( \text{So: NPV} = S - X ) ( \leftrightarrow )</td>
<td>( S - X ) or ( 0 ), whichever is greater</td>
</tr>
<tr>
<td>( \text{Here, a go-no go decision must be taken} )</td>
<td>( \text{Here, it is 'exercise' or not'} )</td>
</tr>
</tbody>
</table>

In other words, the ‘option’ has reached its date of expiration. The option value than can either be \( S - X \) or \( 0 \), whichever is greater. When the option value is negative, the option will not be exercised, which is essentially the same when a project’s NPV is negative: also in that situation the project will not be executed. NPV and option pricing are different in the situation in which a decision can be deferred.

Luehrman (1998a) suggests two new metrics to capture the time value of money and the value derived from changing circumstances: \( \text{NPV}_q \) and cumulative volatility \( (\sigma \sqrt{t}) \).

**\( \text{NPV}_q \)**

The time value of money is the interest which can be earned on the required capital expenditure by investing later rather than sooner. That value can be captured by supposing to put enough money in the bank now so when it is time to invest, the money plus the interest it has earned is
sufficient to fund the required expenditure. That amount is the discounted present value of the capital expenditure, or the present value of the exercise price, \( PV(X) \). This value is computed by discounting \( X \) for the requisite number of periods \( t \) at the risk-free rate of return \( r_f \): \[
PV(t) = \frac{X}{(1 + r_f)^t}
\]
The extra value is the interest rate \( r_f \) times \( X \) compounded over the time periods involved \( t \). To add the extra value to the conventional NPV, the NPV notation needs rewriting from \( NPV = S - X \) into \( NPV = S - PV(X) \), by using the variables introduced in Table 5.8. So, the new metric contains all the usual data captured in the NPV but adds the time value of being able to defer the investment. This new NPV will be greater than or equal to the regular NPV, while it explicitly includes interest to be earned while we wait. Luehrman expresses the modified NPV as the quotient of \( S \) and \( PV(X) \) instead of the difference. In that way, the negative values become decimals between 0 and 1. This new metric is NPVq.

Higher values for NPVq are caused by higher project values \( S \) or lower capital expenditures \( X \). NPVq is also higher when the present value of \( X \) is lower. Higher interest rates \( r_f \) or longer time to expiration lead to lower present values of \( X \).

**Cumulative volatility**

If decision-makers wait, the asset value can change and effect the investment decision for the better. Of course, it is not sure that asset values will change, and, if they do, in what direction they will change. Instead of assessing added value directly, the uncertainty associated with the option can be assessed and quantified. The way to find uncertainty is to assess probabilities. A common probability-weighted measure of dispersion is variance. High-variance assets are riskier than low-variance-assets. Yet, variance alone is insufficient to measure uncertainty; the time dimension should also be taken into account. The extent to which the world can change depends on how long an organisation can afford to wait. Therefore, variance should be taken per period. The total amount of uncertainty then is the variance per period times the number of periods, expressed as \( \sigma^2t \). For the sake of mathematical convenience, Luehrman makes two modifications to this metric. First, instead of using project values, he uses the variance of project returns, i.e. the percentage gained or lost per year: \[
\text{retm} = \frac{(\text{fire vale} - \text{present vale})}{\text{present vale}}
\]
The probability distribution of values is often quite asymmetric: the value can greatly increase but cannot drop below zero. Returns can be
(symmetrically) positive or negative, making their probability distribution easier to work with. Second, using standard deviation ($\sigma$) instead of variance is a lot easier, because it is denominated in the same units as the thing being measured. In summary, the steps taken to express total uncertainty, are:

- Stipulation that $\sigma^2$ denotes the variance of returns per unit of time on the project.
- Multiply variance per period by the number of periods ($t$) to get cumulative variance ($\sigma^t$).
- Take the square root of cumulative variance to change units expressing the metric as a standard deviation rather than variance.

This last quantity is called cumulative volatility ($\sigma\sqrt{t}$). Higher values for $\sigma\sqrt{t}$ are caused by greater uncertainty about a project’s future value and the ability to defer a decision longer.

The two measures can be used to value projects as a European call option (see for an extensive description of this application Luehrman, 1998a). The measures capture the extra sources of value associated with opportunities. The measures are composed of the five option-pricing variables (see Table 5.8) onto which the business opportunities are mapped. As such, they allow to work with two measures instead of five.

Assessment of investment alternatives now becomes the following: NPV (entire proposal) = NPV (alternative under consideration) + NPV (future alternative(s)). The value of the future alternative is determined by using the framework.

**Who**

The method should be used by the decision-makers or the group which prepares investment proposals. Given the sophisticated steps which must be taken, complementing the decision-makers with experts will probably be necessary.

**Inputs**

Value of the first-stage project in terms of the traditional NPV. To determine the value of the option obtained by taking on the initial project, reasonably accurate estimates of the following are needed:

1. value of the second-stage project excluding development cost at the time investment in the first-stage project is being considered;
2. the time before which the option to develop the second-stage project must be exercised;
3. the variance of the expected cash flows from the second-stage project;
4. the risk-free rate of return;
5. anticipated development costs for the second-stage project (which are uncertain at the time investment in a first-stage project is being considered.

**Outputs**
The method results in a ranking of projects, based on adjusted NPV. The reliability of the results is determined by the quality of the estimation of the parameters. Reliability is difficult to determine, the method tries to cope with this by concentrating on the value of waiting: during the course of the first-stage project it will become clearer in which direction the second-stage projects eventually will go to. The time span of the prediction depends on the estimation of the life cycle of the first- and second stage projects. It is clearly longer than using a traditional NPV approach.

**Theoretical support**
The method is grounded in option theory.

**Combination possibilities**
The method makes use of the traditional NPV to value the first-stage projects. Since it is an financial addition to this financial criterion, decision-makers may seek combinations with methods assessing the non-financial aspects of the investment.

**Use in practice and (dis)advantages**
Due the sophisticated methodology, which requires good insight in option theory, the method is not commonly used in practice. An advantage of the method is that it gives hints on how to deal with investments which are strategic and/or deal aimed at infrastructure. A disadvantage is that no support is given for the estimation of costs and benefits and their variance of the second-stage projects (which are highly uncertain and difficult to determine). Evaluating projects as options means that there is more, not less, to analyse. Yet, the Luehrman framework indicates what to analyse, gives a way to organise the effects and offers a visual interpretation.

Besides the extra amount of work to be done, the Luehrman framework has several limitations:

- It assumes that the amount and timing of the project’s capital expenditures ($X$) are certain. This is usually not the case with business opportunities. The framework can be adapted, but only if we can describe the uncertainty. It is necessary to know the probability distribution of $X$ and the joint probability distribution of $S$ and $X$.
- It assumes that the uncertainty remains the same over time. In practice, this will hardly be the case and changing uncertainty will affect the estimate of cumulative volatility. If we know how the variance changes
over time, or if we can make plausible guesses, the framework can be adapted.

The framework does not take into account the (possible) costs of deferral of an investment. Anytime that there are predictable costs to deferring, these costs should be taken into account, making the option less valuable. Thus, the problem is not only to decide whether to invest, but also when. So, value may be lost as well as gained by deferring, and the proper decision depends on which effect dominates.

The Black-Scholes option pricing model which generates the numbers in the table makes some simplifying assumptions, amongst others on the form of the probability distribution of the project returns and whether the assets underlying the options are regularly bought and sold. When these assumptions fail, the framework yields qualitative insights, but the numbers become less reliable.

5.5 Observations and conclusions

In this section we present our observations derived from the previous sections. It is possible to derive ranges of conclusions and hypotheses from the observations, but we limit the conclusions to the development of COMET. After each observation we present the implications for COMET, which may be used as requirement. We derive conclusions from every observation but this does not imply that we eventually will use them all as a requirement. As given in the introduction, we return on this issue in chapter 6.

5.5.1 General observations

All methods show clear advantages and disadvantages. The limitation to the area or dimension for which they are meant is their main weakness. A general critique on the current methods is that they only focus on a particular aspect (only one stage of the decision process, only one criterion of the investment, the investment in relation to other current investments, the investment in relation to future investments, etc.). Only the Information Economics approach and the Kobler Unit Framework try to span all steps in the decision process, by giving suggestions and check-lists to structure the process. The fact that telematics investments are often organisation-wide or even inter-organisational (which can be seen for infrastructure) is under-emphasised by the current methods (cf. Renkema, 1996).

Of course, the decision-makers cannot handle all information which can be provided by using all methods, but the methods mostly do not give clues on how to improve their results if the methods themselves prove to be
unsuccessful. The decision-makers often do not know that other methods for decision support exist.

Bruggeman (1996) concludes that there is no single best method for the selection of investment alternatives in IT. A situation-dependent approach seems to be appropriate. This does not imply to have all methods available within the organisation and use the methods per project which offer the chance of appointing the highest possible budgets at that moment. An organisation should have a systematic approach to investment selection which guarantees a well-balanced investment selection and which contains the following components:

- A breakdown in stages of the investment preparation and selection, with clear procedures and guidelines for the process of identification up to and including evaluation and control.
- A manageable set of selection methods which are tuned to the characteristics of the organisation and the projects usually undertaken by the organisation.
- A system for auditing the investment control.

5.5.2 Specific observations and conclusions for objective setting

Supporting methods for objective setting mainly stem from strategy literature and a myriad of methods is available. Subjects which all methods cover in one way or another are:

- analyses of the organisation, the environment and their relations,
- based on the analysis a search for areas for which investments seem in place (for responsive or preferably pro-active reasons),
- different perspectives on organisational performance (CSF, BSC).

These subjects form the basis of setting objectives and give first hints on which decision criteria to use. What the methods lack is an analysis of what should be input for the decision criteria. In other words, what are the expected effects of the investments and how do these contribute to the decision criteria.

Implications for COMET

The methodology should address the subjects mentioned above as well. This can be done by making use of (parts) of the described methods. In addition, COMET should support a more in-depth approach to searching for effects of the investment which serve as input for the decision criteria. This asks for newly developed components in the methodology.

The criteria used are often only related to money, technology and organisational goals. Criteria which are related to, for example, culture, political relations, work-environment and workload are hardly recognised.
Besides, it seems that no clear theory for used criteria can be given and validation of methods hardly occurs (Renkema, 1996).

*Implications for COMET*

COMET should suggest criteria which are clearly related to the objectives and which will grasp all consequences of an investment. It should be clear why a choice for certain criteria is made.

In addition, the decision criteria should be orthogonal. This means that different criteria may not have the same inputs to prevent double counting.

5.5.3 *Specific observations and conclusions for alternatives generation*

The alternatives generation stage seems to be least developed as far as supporting methods are concerned. Brainstorming is a very general approach (although it can be very effective) and the use of example situations can hardly be called a method. The latter approach should at least be combined with other (pro-active) approaches. Additional methods are also necessary for the strategic option generator, because this method does not offer enough support for concrete investment decisions. When decision-makers started in the objective setting stage with scenario planning, its use in the alternatives generation stage is a logical extension. But also this method needs additions (like brainstorming) to come to concrete scenarios.

No method explicitly supports the alignment between the alternatives generation process and the alternatives assessment process.

*Implications for COMET*

The generation of alternatives and the way alternatives should be constructed in order to properly assess them is one of the practical problems in decision-making on telematics investments. Given the fact that there is only a limited set of methods available, this obliges us to develop new supporting methods in the alternatives generation module of COMET. Of course, where possible, we will make use of the existing methods and special attention will be given to the relation with objective setting and in particular with alternatives assessment.

5.5.4 *Specific observations and conclusions for alternatives assessment*

Financial methods are commonly used in practice and also often serve as a basis for other methods (Information Economics, option theory). Financial methods which take the time value of money into account are more comprehensive than financial methods which do not. Yet, financial methods
(as well as option theory) only focus on financial costs and benefits of the investment and they alone are not suitable to assess strategic investments. Multi-criteria methods take both qualitative and quantitative methods into account.

Option theory offers the possibility to better justify investments which are either strategic in nature or aimed at infrastructure and stimulates decision-makers to think about future purposes of current investments and of alternatives which might occur in the future. Besides, option theory recognises the possibility to reduce risk by waiting (which gives the possibility to acquire new information and profiting from the benefits of the first-stage project).

**Implications for COMET**

COMET should take those (components of) financial methods into account which are able to deal with the time value of money. COMET should also take non-financial (either quantitative or qualitative) methods into account and focus on the problems which typically occur in assessing strategic investments. The methodology should stimulate decision-makers to think about future purposes of current investments and of alternatives which might occur in the future. For a series of investments, COMET can reduce risk by offering the possibility to wait (which gives the possibility to acquire new information and profiting from the benefits of the first-stage project). That is, COMET should apply concepts from option theory if possible.

Multi-criteria methods either are aware that decision-making is a group-process or are actually meant for the support of group decision-making.

A problem with multi-criteria methods (and portfolio methods) is that they are time consuming due to their size, complexity and amount of criteria used. Computerised support may be of help here. Yet, the process of the multi-criteria method is difficult to reconstruct and to verify because the final results are based on (expert) opinions. Also, the interpretation of the final weighed scores of the alternatives within the multi-criteria methods is difficult. Decision-makers should note that the approach is intended to compare results of the different alternatives, the method gives not the absolute value of the results.

**Implications for COMET**

COMET should be aimed at the support of group decision-making, but must be of limited size, with regard to the procedures used and with respect to the number of criteria. The methodology should present clear and unambiguous results, which will not lead to (very) different interpretations.
by different groups. Third parties should be able to reconstruct and verify
the same results by using COMET.

Portfolio methods try to establish a balanced portfolio of investments and
try to relate the necessity to invest in information systems to the current
business operations.

The use of matrices of portfolio methods to compare alternatives with
each other makes it very easy to visibly recognising differences of
alternatives.

**Implications for COMET**

COMET should be able to assess the alternatives in the context of the
participating organisations and (portfolio) of other alternatives, and in
relation to future opportunities. For the decision process, COMET must be
easy to work with and visually attractive (for example by a computer
program with a highly graphical interface).

Ratio methods are useful for benchmarking purposes of current
organisation aspects and not for the ex-ante justification of IT-investments.
The ratio method Return On Management determines the added value of
the management to an organisation. It can be questioned whether
management is willing to use such a method and whether such a method is
useful in assessing investment proposals.

**Implications for COMET**

This observation is of no direct consequence for COMET, while our first
intention with the methodology is to support investment decision-making
and we do not develop it for benchmarking purposes.
Requirements for COMET

In the previous chapters we derived conclusions with respect to theory on decision-making, on telematics investments decision-making in practice and on existing support methods for telematics investment decision-making. In this chapter we validate whether our conclusions hold and as such can serve as a basis for requirements to COMET. In section 6.1 we present the approach we use and the propositions which will be validated. In sections 6.2 - 6.5 we present summaries and analyses results of four cases. The complete case descriptions on which the analysis is based can be found in appendix B. The descriptions are the result of interviews with decision-makers in the respective organisations; the interview scheme used is given in appendix A. All four descriptions are anonymous, while two organisations asked for anonymity as a condition for participation. We end this chapter with an overall analysis and conclusions in section 6.6, leading to a set of requirements for COMET.

6.1 Propositions

We want to improve the quality of the decision-making process by providing a comprehensive support methodology. Overall quality is based on several aspects of the decision-making process. We recognise three groups of aspects: quality of the content and results of the decision process, quality of the process of making decisions and user acceptance of support methods. Each group contains propositions which are derived from the analysis in the previous chapters. The propositions will be validated on their plausibility by means of four cases from practice. We are aware that (scientific) generalisation of case studies is possible to theoretical propositions and not to populations or universes (Yin, 1994). This implies that the case study does not represent a “sample” and hence, we should try
to expand and generalise theories (analytic generalisation) and not try to enumerate frequencies (statistical generalisation).

For each proposition, three outcomes are possible:

- **Support.** We find support for the proposition. The cases can provide three forms of support: organisation or decision-makers behaviour complies with the proposition, the interviewees indicate that the organisation behaved or should behave according to the proposition, or we derive it ourselves from the case description.

- **Rejection.** The cases oppose the proposition. Again, three possibilities occur: organisation or decision-makers behaviour is contrary to the proposition, the interviewees indicate that the organisation behaved or should behave contrary to the proposition, or we derive it ourselves from the case description.

- **Unclear.** In this situation neither clear support nor clear rejection of the proposition can be found.

Each situation will be analysed, with special attention for those situations in which the theses are opposed. Where possible we will analytically generalise the results.

### 6.1.1 Quality of the content/result

**Proposition 1.**

Telematics intertwines with business (chapter 1). Investing in telematics should therefore be part of a business case in which related organisational and telematics investments are described. The description should indicate the business value of the investments.

**Proposition 2.**

Finding the proper decision criteria and effects for telematics investments is difficult (chapter 4). A method should guide the decision-maker in finding the proper criteria and effects.

**Proposition 3.**

Denial of effects of future investments enabled by investments at hand leads to under-valuation of the investments at hand (chapter 5). A method should take into account future investments and their effects.

**Proposition 4.**

In practice, not all effects of telematics investments can be properly expressed in financial terms (chapters 4 and 5). An assessment approach using a combination of financial and non-financial criteria gives more complete insight into business and (inter-) organisational effects, process effects and technical effects.

**Proposition 5.**

For better insight into the effects of inter-organisational telematics investments it is necessary to analyse business processes not only from an internal organisations perspective, but at a chain or network level as well (chapters 1 and 4). A method should have a chain perspective to obtain insight into the effects which occur in the chain or network.
Proposition 6.a. In decision processes often many (groups) of participants are involved in different stages (chapter 2, 4 and 5). A support method should contain a mechanism for supporting the transfer of results from one group to another within decision processes, as such improving communication.

Proposition 6.b. Decision-makers have problems in making use of learning experience from previous projects (chapter 4). A memory in a support method leads to improvements in decision-making in the long run because it can grasp learning experience and forms a basis for knowledge management systems.

6.1.2 Quality of the process

Proposition 7. Decision-making on telematics investments can be seen as a cyclic process, in which each cycle contains the stages objective setting, alternatives generation, alternatives assessment and choice. The business objectives, alternatives and assessment results are iteratively refined (chapter 2). A support method should follow the lines of the decision-making process.

Proposition 8. The decision process is complex (chapters 2, 4 and 5). A method should structure the decision process by recognising the cycles and stages and supporting the stages in every cycle by separate modules, thus reducing complexity of the decision process.

Proposition 9. In decision processes usually several participants with different objectives are involved (chapter 4 and 5). A support method should support the explicit recognition of their roles and provide the participants with the possibility to individually or jointly perform their roles. Thus, commitment from parties interested and reduction of potential sources of conflict is attained.

6.1.3 Use and acceptance

Proposition 10. No new method to support decision-making is easily accepted by decision-makers and users (chapter 1, 4 and 5). Combining (parts of) existing and accepted decision support methods in a comprehensive methodology lowers the threshold for decision-makers to use the entire methodology, because of their acquaintance with these methods.
6.2 The case of transport organisation TA

This case describes the decision process on the introduction of EDI within a transport organisation, which we named “TA”.

6.2.1 Summary

Transport organisation TA is a family-owned and operated company, which currently exists 27 years. The main activity is transport, in which air-freight trucking accounts for approximately 70%. The core activities are international transport, national transport (distribution) and warehousing. TA’s head office is located in the Netherlands, while several local offices are present at airports throughout Europe. TA operates circa 300 trucks and employs about 500 people. The main customers of TA are airlines for international transport and air-freight forwarding companies for national distribution. Next to them, TA has some customers which ask for specialised transport, while they ship high value goods, such as electronics and medical equipment. TA plans to expand Value Added Logistics activities.

The decision process can start in several ways and is not linear: somebody in the organisation proposes ideas or the organisation is confronted with new technology which might be interesting. In the next step, TA determines whether the new technology can be applied and whether it is technically feasible. TA roughly determines the possible advantages and disadvantages and whether the project can be realised for a reasonable price.

The overall objective for TA is to make profit and to achieve growth. TA has a corporate strategy in which IT plays an important role. The goals and strategy are (continuously) dynamically determined. The added value of IT is tested against the goals stated in the strategy. IT and telematics are very important for TA and have top priority. TA continuously strives for improvement of processes by means of IT, in order to augment efficiency and, when possible, effectiveness. Savings of process costs are important because the margin of TA is under continuous pressure. Another reason to invest in IT is to establish an innovative image, which is seen as a strategic issue.

In the case, an investment trajectory in an EDI-application for communications with the customers is discussed. The EDI-investment was not done in isolation, but rather a step-wise approach was used, in which the application was extended and improved into its current form.
6.2.2 Analysis

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT and telematics are very important for TA and have top priority. However, the organisation did not describe the investments in the organisation and the application in parallel. This opposes the proposition. Yet, when telematics is a strategic issue at least a relation between IT and the business processes needs to be sought. Furthermore, the organisation shows difficulties in determining the effects of the investment to the organisation.</td>
</tr>
<tr>
<td>2</td>
<td>TA does have problems in finding the proper criteria and effects of telematics investments. This supports the proposition. The interviewees indicated that the organisation would use a method to support the assessment, but wonder whether such a method can be developed.</td>
</tr>
<tr>
<td>3</td>
<td>This proposition is implicitly supported by the fact that TA did directly choose to offer five instead of three levels of communication, opening possibilities for a broader group of customers to electronically communicate with TA. Furthermore, TA chooses standard solutions, making future expansion as simple as possible.</td>
</tr>
<tr>
<td>4</td>
<td>TA did determine a payback period for the financial effects. Although values for non-financial effects are hard to determine for this kind of investments, TA used several non-financial criteria, such as competitive advantage and organisational image. This supports the proposition. Furthermore, especially the justification of IT is felt to be difficult, because of the fact that the contribution of IT to the organisational results is indirect through the support of business processes.</td>
</tr>
<tr>
<td>5</td>
<td>Both TA and its first partner analysed the possibilities of EDI for their organisation and analysed each others systems, information flows and way of working. This supports the proposition. On the other hand, TA does not want to integrate with partners, because separations along the lines of the organisation can be clearly defined and makes a better structuring of the information possible. Besides, the separation is based on security issues.</td>
</tr>
<tr>
<td>6a</td>
<td>No clear support for this proposition is found. The various steps in the decision process are executed by different participants, but it is unclear whether communication problems existed.</td>
</tr>
<tr>
<td>6b</td>
<td>TA used its experience with a previous project to estimate the cost and benefits. On the basis of that experience and the organisational strategy, TA knew which decision criteria and effects should at least be taken into account in the project. However, the interviewees indicated that such experience quickly fades and that they would use a memory in the form of a checklist. They would put down for what reasons a certain investment is chosen and what its results are. It can be particular useful to compare different projects which are executed at different moments in time. This supports the proposition.</td>
</tr>
<tr>
<td>7</td>
<td>TA used a formal approach for the project, partly because this was a requirement to obtain a subsidy. The case description shows that the organisation took several steps to come from the objective to the implementation of the investment. This supports the proposition. Whether a support method should follow the lines of the decision-making process remains unclear.</td>
</tr>
<tr>
<td>8</td>
<td>No clear support for this proposition is found.</td>
</tr>
</tbody>
</table>
9 In the EDI-project, TA and its first partner had different and mutual objectives, leading to a joint effort in developing a complete message scenario and to individually determine the technical needs and necessary adaptations of the organisation. As such, an implicit division of roles was made and implicit support for this proposition is found. Commitment was gained by the fact that both parties had to invest in the application. It is unclear whether the organisations used or need an approach to structure the process.

10 No clear support for this proposition is found. However, TA appears to use standard methods, such as payback and common criteria such as competitive advantage and increase in turnover.

6.3 The case of container terminal operator CTO

This case describes the decision process on the introduction and use of EDI within a container terminal operator, which we named “CTO”.

6.3.1 Summary

CTO is a terminal operator which is active since 1969. The main activity is transhipment: loading and unloading of ships, and delivery through the modalities road, rail and inland navigation. CTO operates five terminals, each of which has its own customers and way of handling. CTO has a board of directors which give direction to two divisions. The annual turnover is f650 million and CTO employs about 2100 people and approximately 300 flex-workers. CTO spends approximately 8% of turnover on total IT. Every day 2000-2500 trucks arrive at the gates of CTO. CTO handles 2.5 million containers at the sea-side. At the land-side 1.9 million containers are handled, leaving 0.6 million containers for sea-sea transhipment. Approximately 70% of total container handling within the harbour is performed by CTO.

In 1989, CTO developed a structured plan for EDI. This plan led to one vision among the different decision-makers. A plan like that forces organisations to consider various aspects of EDI: which priorities need to be determined, what volume of transactions is under consideration, what is our external environment, what are the large players, what are the small players, do we start at the sea-side or at the land-side, do we develop the components ourselves or not, etc. The development of the plan took several months and acquired reasonable consensus. A problem was that the group working on the plan was small relatively to the rest of the organisation. Looking back at that period leads to the conclusion that no solid base for EDI existed within the operational departments (mainly because they had never been confronted with EDI developments). The plan was developed at management level and consisted of several components emphasising both...
external and internal aspects. The internal part consisted of an information sessions part and an IT part. Many internal information sessions were held to explain management expectations with regard to EDI. Such sessions are still in use, for example to gain support for new developments. Currently the EDI plan is no longer in use. At the sea-side, CTO has developed a complete scenario, at the land-side the success depends on two projects which are currently undertaken by CTO and many other organisations within the harbour community.

6.3.2 Analysis

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Support</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>CTO started with treating EDI in isolation. Yet, currently the organisation uses an integrated approach towards telematics investments. The telematics investments are linked to IT-projects or linked to projects in which organisational changes are undertaken. As such, the investment forms part of a larger business proposal and its results must be described in terms of the business value it creates. This supports the proposition.</td>
</tr>
<tr>
<td>2</td>
<td>No clear support is found. Yet, the overwhelming positive financial impact as determined by a cost-benefit analysis makes it relatively easy to judge the investment on the sole basis of a financial criterion. As such, the organisation will probably see no problems in determining the criteria and effects.</td>
</tr>
<tr>
<td>3</td>
<td>When investing in telematics, CTO tries to take into account new possibilities and business redesign and by adopting generic solutions, electronic communication with other kinds of organisations (banks, government) become possible. The EDI benefits then turn out even more positive. Furthermore, for the development and assessment of alternatives, especially for infrastructure, CTO would probably make use of investment graphs when they exist and are easily in use. This supports the proposition.</td>
</tr>
<tr>
<td>4</td>
<td>No clear support for the proposition is found. From the description it is unclear whether all effects of the investment could be expressed in financial terms. Yet, those aspects which could be made financial delivered a very clear positive result for the investment and served as the main basis for the decision. The organisation also used customer service and product quality as decision criteria. Whether the criteria are hierarchically related to each other or used in parallel is unclear.</td>
</tr>
<tr>
<td>5</td>
<td>This proposition is supported. CTO sees itself as a small part in a very large logistic chain and constantly searches for ways to tie customers to itself. Furthermore, many initiatives in which the (entire) harbour community is involved are taken.</td>
</tr>
<tr>
<td>6a</td>
<td>This proposition is supported. CTO usually has to come to an agreement with (large) partners who all have different objectives and priorities. Given the experience with those agreements, according to the interviewees, CTO would appreciate the use of a memory to support decision-making. This can help to remember which party suggested what requirements at a certain moment and forgot later on in the process. It would also enlarge commitment of organisations involved.</td>
</tr>
<tr>
<td>6b</td>
<td>This proposition is supported. By properly documenting the steps taken in the decision process, transfer from information between employees across time will be easier according to the interviewees.</td>
</tr>
</tbody>
</table>
The approach towards EDI followed a hierarchical line from strategy development to actual implementation. From the description of the case, steps in the process can clearly be seen. This supports the proposition. The interviewees indicated the need for support of several steps, whether an overall support method is necessary, is unclear.

CTO feels that the decision process is complex and that steps are taken very slowly, especially in inter-organisational situations. This supports the proposition. Whether an overall support method is necessary, is unclear

In decision processes of CTO, both internally and externally, different stakeholders are involved. Indicating a clear role for each participant would enlarge commitment and reduce sources of conflict. This supports the proposition.

No clear support for this proposition is found. Yet, the organisation is familiar with financial methods and makes use of multiple criteria. Moreover, the interviewees state that the organisation would use methods such as a memory and investment graphs.

6.4  The case of building material producer BMP

This case describes the decision process on the introduction and use of EDI within a building material producer, which we named “BMP”.

6.4.1  Summary

BMP is a producer of building materials. BMP produces autoclaved aerated concrete, both for the construction industry and for the DIY-market. It is produced in various formats, according to principles of modular design. BMP owns and operates 24 continuously working plants and is active in 19 countries. The holding is located in Germany. World-wide BMP employs 2900 people, in the Netherlands approximately 500. The Dutch branch consists of a head office, three mills and a factory producing glue. The Dutch turnover is f130 million, world-wide turnover is DM 867 million. The main customers of BMP are trade organisations in building material, building contractors and construction industry, large chains of DIY-markets and purchase alliances of smaller DIY-markets. BMP has several competitors, mainly determined by the use of material, such as steel and plaster. Because of their bulkiness, most raw materials are delivered at the mills by water. The suppliers of BMP are large. The environment of BMP constantly changes: the markets, legislation (with regards to working conditions and the environment), introduction of the Euro-currency, year-2000 problems, etc.

The decision process at BMP is executed along the line of the ‘foolproof’ method of Cap Gemini. This approach consists of the stages problem analysis, objective setting, alternatives generation and advise to management, and finally, a choice is made. Setting objectives is seen as the most important aspect of the decision process. BMP has a business plan
from which operational plans (such as for IT) are derived. The IT plan has a horizon of one year and IT projects stem from this plan. The plan also determines IT budget, which mainly aims at maintenance and control. Budget determination takes place on the basis of results of the previous year and expected developments. Expectations are related to organisational growth and clear changes in the environment (such as the Euro-currency and the year-2000 problem). The budget is fairly constant.

Ideas regarding the use of EDI developed in 1990, as a result of EDI developments in the transport sector. A stimulus for the introduction of EDI within BMP was the fact that subsidies were available. The main reason to start the EDI project with large partners was the possibility of cost savings for all parties. Other reasons were the possibility to quicker send information and to be more quickly informed. This, on its turn, makes it possible to better steer and control stock which brings JIT production in sight.

6.4.2 Analysis

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For the EDI project, a project team was formed and in separate groups all aspects of the investment (technical, financial, organisational and juridical) were analysed and described. Besides, the fact that BMP did not continue to use the stand-alone version of EDI due to expected operational problems, implies that BMP did not see EDI development separate from organisational development. This supports the proposition.</td>
</tr>
<tr>
<td>2</td>
<td>BMP does not have problems in finding the proper decision criteria. The organisation does however have problems in finding the proper effects and thinks its hard to set good objectives. A tool which can be used to indicate the advantages of EDI is seen by the interviewees as a useful mechanism and could be used by the branch organisation as a service towards its members. This partly supports the proposition.</td>
</tr>
<tr>
<td>3</td>
<td>No clear support for this proposition is found. However, the interviewees indicated that, when presented in a user friendly manner, BMP would use investment graphs. Such graphs would be particularly useful in convincing the traders in building material of the usefulness of EDI.</td>
</tr>
<tr>
<td>4</td>
<td>Within the decision process, BMP would like to have support for the quantification of the benefits, especially for the ones which are difficult to express in money terms. This supports the proposition. Besides, for the EDI project, BMP performed a cost-benefit analysis, in combination with a multi-criteria approach and separately analysed all aspects of the investment.</td>
</tr>
<tr>
<td>5</td>
<td>By analysing the costs and benefits, BMP regarded the business processes at a chain level. Besides, for BMP it was very important that within the project all participants should realise positive results. This supports the proposition.</td>
</tr>
</tbody>
</table>
This proposition is supported. A memory in the form of a database would be used by BMP to support the decision process (a project database in Lotus Notes is actually in use). This can support the alignment of ideas of those proposing projects and those who make the decisions. Management must be able to understand what the proposed projects imply and why they are important to the organisation. The line of reasoning is clearly different between the two groups.

BMP would use a memory to share information, even to eventually share it with partners. In the form of a database, a memory makes searching for information possible and easier than searching in a traditional archive. This supports the proposition.

The ‘foolproof’ method of Cap Gemini is used by BMP and consists of the stages problem analysis, objective setting, alternatives generation and advise to management. Finally, a choice is made. This approach almost exactly runs as described by the proposition.

By using the ‘foolproof’ method of Cap Gemini, BMP explicitly structured the decision process. Whether a modular support method was necessary, is unclear.

All aspects of the project were covered by separate project teams, consisting of people from all parties involved. It reduced lead-time and a shared focus on results was attained. This supports the proposition. Furthermore, BMP learned that projects can have difficulties when communication between developers of IT and users of IT is not properly taken care of. The developers need to communicate very clearly what they are about to develop and prevent a technology push approach. If users are not involved in the development they are hard to convince of the need of the product for their work and show a tendency to refrain from using it.

BMP performed a cost-benefit analysis, in combination with a multi-criteria approach. These methods can be combined in a methodology. According to the interviewees, BMP would also use investment graphs and a memory when presented in a user friendly manner. This supports the proposition.

### 6.5 The case of travel group TG

This case describes the decision process on a new IT strategy within a travel group, which we named “TG”.

#### 6.5.1 Summary

TG is an independent operating travel organisation and is part of a holding company. The holding company has two other daughters: a travel organisation in the USA and an independent IT organisation which offers IT products to the travel industry. TG is divided in two business units. One is aimed at the tourist sector and employs about 250 persons at 83 travel shops spread throughout the Netherlands. The other unit aims at the business traveller and employs close to 150 persons at 17 locations. This latter unit can be further sub-divided in ‘general’ shops where every business traveller can book trips, and ‘in-plants’: travel agencies of large companies which are managed and operated by TG. Both business units
have the same share in turnover of TG. Besides these business units, TG recognises several staff functions at the corporate level: human resources management, quality management and IT. The head office employs approximately 90 persons.

Until recently TG had a top-down decision process in which management took all decisions on investments. Investments were done in activities of which management thought it could be useful for the organisation. No extensive cost benefit analyses were performed. That approach was possible because the organisation used to be relatively small and an overview was easy. Currently, the approach towards investment decision-making becomes more formal, but TG is only at the brink of the changes which will have to be executed. The decision process should have clear steps in which first the objectives are determined, next alternatives are generated, then an assessment is made which can lead to choice.

Although the market is very dynamic and it is hardly possible to look further than a year ahead, TG foresees a clear picture of its own future. It is not written down, but TG's aim is to become the number 1 in business travel and to grow significantly in tourism. TG recognises the importance of the use of new technology to reach those objectives. In 1997, TG executed a small project which clarified the importance of the use of technology. In the months which followed that project, TG has worked out the consequences for the organisation of the vision stated in the project. The project was initiated and sponsored by the IT department, but currently not only has an IT part, but also a very large organisational part. IT management has convinced management that fairly large investments in IT are necessary, but that at the same time ideas from operations should be aligned with the investments, to prevent investing in nifty applications which will not be used.

6.5.2 Analysis

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The first explorative project was initiated and sponsored by the IT department, but currently not only has an IT part, but also a very large organisational part. IT management has convinced senior management that fairly large investments in IT are necessary, but that at the same time ideas from operations should be aligned with the investments, to prevent investing in nifty applications which will not be used. The interviewees stated that TG should prevent that all organisational changes are triggered by IT investments and take place under the control of IT management. To overcome this problem, a future approach can be the outsourcing of parts of IT. This supports the proposition.</td>
</tr>
<tr>
<td>2</td>
<td>TG did not used to perform cost-benefit analyses and finds it difficult to quantify expected effects of investments. It searches for methods to justify investments. This supports the proposition.</td>
</tr>
</tbody>
</table>
3 By investing in a new network necessary for the services related to the Central Reservation System (CRS), TG can also provide new functionality, which on its turn can deliver new benefits. By coupling the switch of CRS to the IT investments, a quick generation of benefits is linked to in-depth investments. By constantly presenting the benefits of the investments to management, IT management is able to step by step execute the necessary investments. It is essential to make clear why certain investments are made and how they are justified. In every next step, each investment must be analysed further to clearly show its benefits (savings). This supports the proposition. Moreover, TG would also use investment graphs when they offer insight into dependencies between investments and enable the projection of future investment trajectories.

4 TG has difficulties in properly expressing all effects in financial terms. However, the interviewees clearly opt for making the effects financial where possible by searching for methods to express the non-financial effects in financial terms. By means of activity based costing, TG tries to find out whether and how different products can be determined and whether a cost price for those products can be established. As such TG uses multiple criteria which eventually are combined in financial terms. This supports the proposition.

5 For investments in a CRS, TG has to use a chain perspective. Next, for standardisation of information exchange, a project has started in which tour operators, CRS and customers jointly try to come to exchange standards before the year 2000. This supports the proposition. Yet, TG finds itself between the demands and requirements of both its suppliers and customers. To prevent too large an influence at the organisation, TG tries keep suppliers and customers outside the (IT) border of the organisation as much as possible.

6a TG would certainly use a memory in which the different steps taken in the decision process, decision criteria and expected costs and benefits are saved, mainly because it is important for the continuity of projects. Besides, TG feels that interaction between management and the people who determine IT functionality is very important. This supports the proposition.

6b For this proposition no clear support is found.

7 TG did not have an approach as suggested by the proposition, but slowly grows into a more formal approach. This formal approach exactly follows the steps as described by the proposition and a such supports it. Because the organisation grows into the process, a supporting method which follows the lines of the decision process seems appropriate.

8 Because the organisation grows into the new way of using the decision process, a supporting method which indicates the lines of the decision process and offers support for every step seems appropriate.

9 The interviewees feel that interaction between management and the people who determine IT functionality is very important. This requires methods which are user-friendly. The interviewees stated that within the implementation trajectory it is very important that management of the business units is urged to take the necessary steps and that it is also necessary to make somebody responsible for the control of methods and means which can be used to justify investments. All these arguments implicitly support the proposition.
TG currently uses cost-benefit analysis and activity based costing. According to the interviewees, the organisation would also make use of investment graphs and a memory. These components within a comprehensive methodology would probably be used by the organisation. This supports the proposition.

6.6 Overall results and requirements for COMET

In this section we present the overall results of the cases and analyse the consequences of the results for the development of the methodology. The section ends with an overview of the requirements to which (the development of) the methodology should comply.

6.6.1 Overall results of the cases

In Table 6.5 we summarise the results of the analysis of the propositions by means of the cases. For each result is given between brackets how it is derived.

<table>
<thead>
<tr>
<th>Proposition</th>
<th>TA</th>
<th>CTO</th>
<th>BMP</th>
<th>TG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unclear (R)</td>
<td>Support (C)</td>
<td>Support (C)</td>
<td>Support (C/I)</td>
</tr>
<tr>
<td>2</td>
<td>Support (C/I)</td>
<td>Unclear (C)</td>
<td>Support (C/I)</td>
<td>Support (C)</td>
</tr>
<tr>
<td>3</td>
<td>Support (R)</td>
<td>Support (C/I)</td>
<td>Unclear (C)</td>
<td>Support (C)</td>
</tr>
<tr>
<td>4</td>
<td>Support (C)</td>
<td>Support (C/I)</td>
<td>Support (C)</td>
<td>Support (C)</td>
</tr>
<tr>
<td>5</td>
<td>Unclear (R)</td>
<td>Support (C)</td>
<td>Support (C)</td>
<td>Support (I)</td>
</tr>
<tr>
<td>6a</td>
<td>Unclear (R)</td>
<td>Support (C/I)</td>
<td>Support (C)</td>
<td>Support (I)</td>
</tr>
<tr>
<td>6b</td>
<td>Support (C/I)</td>
<td>Support (I)</td>
<td>Support (I)</td>
<td>Unclear (R)</td>
</tr>
<tr>
<td>7</td>
<td>Support (C)</td>
<td>Support (C/I)</td>
<td>Support (C)</td>
<td>Support (R)</td>
</tr>
<tr>
<td>8</td>
<td>Unclear (R)</td>
<td>Unclear (R)</td>
<td>Unclear (C)</td>
<td>Support (R)</td>
</tr>
<tr>
<td>9</td>
<td>Support (C)</td>
<td>Support (C)</td>
<td>Support (C)</td>
<td>Support (I)</td>
</tr>
<tr>
<td>10</td>
<td>Unclear (R)</td>
<td>Unclear (I)</td>
<td>Support (C/I)</td>
<td>Support (I)</td>
</tr>
</tbody>
</table>

Explanation: C = result stems from the case
I = result indicated by interviewee
R = result observed by us

The analysis of the cases did not lead to a clear rejection of the propositions. Yet, only proposition 7 and 9 gained support from each case, while for all other propositions at least one case rendered an unclear result. This makes it questionable whether the methodology should comply or deal with the descriptions given in the propositions. We can approach this issue in two manners.

The first approach is to perform additional case research for additional results. This can be done by finding new cases and/or by returning back to
organisations described by the current cases. A problem we may encounter then is that this may also render unclear results. Besides, the table above may suggest seeking for statistical generalisation of the propositions by counting the number of supporting cases. This generalisation is not possible and adding new material will not alter this.

The second approach is to start building the methodology on the basis of the current requirements where the unclear results should be taken into account as critical notes on the basis for the methodology. In that situation these critical notes should in particular be addressed when testing a version of the methodology in practice (by means of case research!).

Since no rejections of the propositions are found, a choice is made for the second approach. In other words, we take the generic requirements introduced in chapter 1 as a starting point and will use the structures, concepts, methods, requirements and implications introduced in chapters 2-5 to construct the methodology.

### 6.6.2 Requirements to COMET

This section gives a summary of the requirements to the methodology introduced in the previous chapters.

**General requirements**
- COMET should be comprehensive (chapter 1).
- COMET should be structured (chapter 1).
- COMET should be inter-organisational (chapter 1).
- The decision process model is based on the concepts from the bounded rationality model possibly added with concepts from the political model (chapter 2).
- The decision process model has a cyclic character (chapter 2).
- Each cycle in the decision process model contains the stages (chapter 2)
  - setting an objective,
  - searching for alternatives,
  - assessment of the alternatives, and
  - making choices.
- Although the decision process is seen as a structured set of activities, this does not imply that the whole decision process is fixed. The structure should be flexible enough to be adapted to particular circumstances (chapter 2).
- COMET should be able to support the different groups involved in the decision process by means of a clear structure or format and by methods which the respective groups understand (chapter 4).
COMET should support a proper (that is: clear and unambiguous) transfer of information and knowledge from one stage to another in the decision process (chapter 4).

COMET itself should have a mechanism to capture and hold experience gained in previous stages of the decision process and in previous projects (chapter 4).

Third parties should be able to reconstruct and verify the same results by using COMET (chapter 5).

For the decision process, COMET must be easy to work with and visually attractive. For example by a computer program with a highly graphical interface (chapter 5).

**Requirements to supporting objective setting**

- COMET should see telematics as part of a business proposal (chapter 1).
- COMET should support the clarification of the contribution of the telematics investment to the objectives. It should therefore make clear the relation between the objectives, between the objectives and the business processes and between the business processes and the telematics investments (chapter 3).
- COMET should contain methods to execute a complete SWOT analysis (chapter 4).
- COMET should suggest decision criteria which can be used and/or support a structured approach in deriving decision criteria from the investment objective (chapter 4).
- Within objective setting, COMET should support (chapter 5)
  - analysis of the organisation, the environment and their relations,
  - the search for areas for which investments seem in place (for responsive or preferably pro-active reasons),
  - different perspectives on organisational performance (CSF, BSC).
- COMET should suggest orthogonal criteria which are related to the objectives and will grasp all consequences of an investment (chapter 5).

**Requirements to supporting alternatives generation**

- Next to the direct effects, external effects and the linkage effects, or in other words, the effects to other stakeholders should also be addressed. When possible, they should be internalised in the decision (chapter 3).
- COMET should recognise the fact that the introduction and implementation of telematics investments usually follow a step-wise path, making future investments dependent of past or current investments (chapter 4).
- COMET should support a more in-depth approach (than current methods have) to searching for effects of the investment which serve as input for the decision criteria (chapter 5).
Within COMET, new support methods for alternatives generation should be suggested (chapter 5).

The methodology should stimulate decision-makers to think about future purposes of current investments and of alternatives which might occur in the future (chapter 5).

Requirements to supporting alternatives assessment

- COMET should permit the combined assessment of consecutive investments (chapter 1).
- COMET should support estimation of all important effects (chapter 1).
- The expenses and revenues of the entire life cycle of the telematics alternatives should be addressed by a cash flow analysis. This analysis should be a part of the assessment module of COMET (chapter 3).
- COMET should offer possibilities to find and assess qualitative effects, most likely in addition to the financial CBA (chapter 3).
- Within COMET the alternatives first must be assessed on their individual merits. Then, they must be confronted with each other and with a ‘base case’ which represents a prolongation of the initial situation (chapter 3).
- Within COMET valuation of investments should be based on all effects of the investment. This means that all contributing effects should be valued (chapter 3).
- Within COMET the NPV will be used. The assessment module of COMET will contain more existing methods, allowing for analyses on different effects (financial, quantitative or qualitative) (chapter 3).
- To both meet the assessment demands and maintain freedom for the decision-makers to choose a certain assessment method, COMET should offer a range of assessment possibilities (chapter 4).
- COMET should trigger and support proper assessment of alternatives, provide tools to indicate external dependencies and support the generation of realistic targets (chapter 4).
- COMET should take those (components of) financial methods into account which are able to deal with the time value of money. COMET should also take non-financial (either quantitative or qualitative) methods into account (chapter 5).
- COMET should be able to assess the alternatives in the context of the participating organisations and (portfolio) of other alternatives, and in relation to future opportunities (chapter 5).

Requirements to supporting choice

- COMET should present clear and unambiguous results, which will not lead to (very) different interpretations by different groups (chapter 5).
PART II — A first design of COMET

In this part of the book, we introduce a first outline of COMET based on the requirements derived in the previous chapters. In chapter 7 we discuss the overall structure of COMET. Then we discuss in chapters 8-11 the structure and contents of each individual module within the methodology, as well as the relation between the modules. In chapter 11, we will discuss the choice module and the role of a memory in COMET.

To illustrate the components of COMET and their use, we will use a running example in this part of the book. The example is inspired by the case of travel group TG, as described in chapter 6 and appendix B, but is fictitious. An introduction of the case is given below.

The case describes TG, an independent operating travel organisation which is part of a holding. The holding also contains a travel organisation in the USA and an independent IT organisation which offers IT services to the travel industry. TG is divided into two business units. One is concerned with the tourist market and the other with the business traveller market. TG faces great turbulence and major shifts in its markets. Until recently, TG had a top-down decision process, in which management took all investment decisions. TG invested in those products and activities which its management considered to be useful for the organisation. No extensive cost-benefit analyses were performed. TG’s management thought that these analyses were not really necessary, because the organisation used to be relatively small and therefore informal analyses of the impact of an investment were considered to be sufficient. Currently, the approach towards investment decision making becomes more formal, but TG is only at the brink of the changes that will have to be executed.

In the consecutive chapters we suggest various methods to be used in the respective modules. The choice for existing methods is based on their analytical comprehensiveness, their possibilities of combining them with other methods and their ease of use for practitioners. Use of these methods is not obligatory and users of COMET are free to use other methods that they may find more easy or suitable for their particular situation (if they fit in COMET). Other methods can be found in chapter 5 and in Robson (1997).
Overall structure of COMET

The overall structure of COMET is in line with the model of decision making as presented in chapter 2. In this chapter we discuss the modules of COMET, the cyclic nature and cycle-groups of COMET, the assessment approach, the domains we can distinct for objectives, investments and effects, and the use of a base case.

7.1 COMET modules

COMET is divided in modules, which support the various stages of the decision process as described in chapter 2. Hence, COMET offers comprehensive support for the entire decision process. The explicit separation of modules and tasks within these modules clarifies for decision-makers in which stage of the decision process they find themselves.

COMET contains the modules objective setting, alternative generation, alternative assessment and choice (see Figure 7.1). The modules are interrelated: outputs of the former are inputs for the latter. Hence, the
results of a module should have a form suitable for the next module to use them as input. Where possible, the modules consist of (components of) existing methods (see chapters 8 - 11).

COMET contains a considerable amount of flexibility, offering its users the freedom of choice in methods, decision criteria and effects to be measured. For example, COMET suggests to use certain decision criteria, but these suggestions are not fixed and no suggestions for target values are given. The decision-makers have to choose the criteria and the target values, which implies that they have to perform substantial preparatory work. This work is mostly done in the first module.

7.2 COMET cycles

COMET's modules may suggest a top-down approach to decision-making: from setting the objectives down to reaching a decision. In practice, decision making does not follow a strict top-down trajectory. Therefore, COMET has a cyclic model of decision making (see chapter 2), allowing decision-makers to adapt, expand, or refine the results (alternatives, effects assessed) in a subsequent cycle. The relation between cycles is deliberately kept loose, so that traversing one cycle hardly restricts the decision-maker in following cycles. A consequence of this however is that the decision-maker himself is responsible for making the cycles converge into a final decision.

In other words, COMET is not designed from the opinion that a fixed set of steps should be traversed in a fixed order. Yet, COMET forces the decision-maker to make the different results and intermediate results in the process explicit and consistent. Hence, explicitness and consistency are crucial. The order of the steps is less relevant.

COMET allows addition of new alternatives in new cycles. Addition of alternatives causes (temporary) divergence of the decision process. Next to that, COMET comprises two converging mechanisms between cycles, the sieve and the magnifying glass (see Figure 7.2).
The sieve is used between cycles when the set of alternatives under consideration in a certain cycle is a subset of the set of alternatives of the previous cycle. In this case, the choice stage in the previous cycle led to the decision to discard certain alternatives and continue with the (one or more) other(s).

The magnifying glass is used between cycles when an alternative under consideration in a certain cycle is a refinement or part of an alternative of the previous cycle. The alternative generation stage in the new cycle subsequently takes care of this refinement (see chapter 9).

Often, the sieve and the magnifying glass are both used between two cycles: the sieve in the former cycle leads to a smaller set of alternatives which are to be refined by the alternative generation stage of the latter cycle.

The decision process ends when consecutive sieves have restricted the set of alternatives into a single alternative and consecutive magnifying glasses have sufficiently refined an alternative, so that it can be used for implementation.

Running example:
The sieve and magnifying glass at TG
In the second cycle TG analyses alternatives B and C on their technical aspects. By analysing the hardware and software needs of the alternatives, TG learns that alternative B can run at two different operating systems. Since TG uses both operating systems, it is decided to take the two variants of B into account in the consecutive steps of the decision process. Here, TG applies the magnifying mechanism and this decision cycle renders the set of alternatives B1, B2 and C.

In new decision cycles, TG can apply both the sieve and magnifying glass again to eventually find an alternative which meets TG's objectives.

7.3 COMET cycle-groups

COMET recognises two different types of decision cycles. In the first type of cycle, the coarse cycles, the focus is on analysing the organisation and its environment. Objectives are set and alternatives are coarse. In the second type, the fine cycles, the objectives are set and the focus is on assessing and detailing the alternatives. The objectives will be refined and alternatives are made concrete. This distinction causes the COMET modules to contain different decision support methods for different cycle-groups. In the following sections we will indicate which methods are found in which cycle-groups. The differences will mainly become clear in the objective setting module and, to a lesser extent, in the alternatives setting module and the alternatives assessment module.

7.4 Two-stage assessment

In assessing the full impact of a telematics investment, decision-makers are confronted with the tension between comprehensiveness and manageability of both the process and the results. In COMET we therefore distinguish effects and decision criteria and use a two-stage assessment approach. In this approach, first all effects of the alternatives are investigated and valued after which they are combined into the defined decision criteria.

7.5 Domains

When speaking about investments and their effects, it is important to explicitly determine the scope of an investment, that is, to which part of an organisation, to which organisation, or even to which organisational network the investment applies. Hereafter, we refer to the process, organisation or network for which the investment is intended as unit (of analysis).
Yet, three domains may be distinguished in a decision process: the objective domain, the investment domain, and the effect domain. Often, these domains will be different, even within a single decision process. We therefore elaborate on the domains and their differences in the next three subsections.

7.5.1 **Objective domain**

The objective domain is the domain to which the objectives that are set in the objective setting module apply. The objective domain may be an organisation’s department when the efficiency of that department must be improved. It may be an organisation when it is the objective to enhance the agility of that organisation. And it may be a chain of organisations in case the overall lead-time should be shortened by e.g. 10%. Each objective has its own objective domain. The general objective domain is defined as the union of all individual objective domains. The general objective domain should include all stakeholders with recognised interest in the investment and involved in the decision process.

7.5.2 **Investment domain**

The investment domain is the domain to which a certain investment alternative applies. It consists of the (parts of) organisation(s) that are actually changed by the investment. For instance, in case of an EDI investment between two organisations, the investment domain may be the ordering process of one organisation and the order handling process of the other.

Each investment alternative has its own investment domain. For a decision process to make sense, however, all investment domains should be covered by the decision-makers.

7.5.3 **Effect domain**

The effect domain is the domain in which the consequences of an investment (i.e. effects) occur. The investment will impact and alter the current situation, thus leading to a new situation, with a new performance, as given in Figure 7.3.
As mentioned in chapter 1, the implications of telematics often reach beyond or outside the investment domain (cf. Symons, 1994). These implications are called secondary effects which we defined in chapter 3 as effects outside the unit(s) in which the investment is to be carried out. The secondary effects may be substantial and may even be the reason to undertake an investment. They therefore should be taken into account and 'secondary' should not be seen as 'less important'. An explicit distinction between investment domains and effect domains should be made, so that secondary effects can be taken into account.

In Figure 7.4 two forms of secondary effects are given. In the left-hand picture 'neighbour' effects are given: investing in process X leads to secondary effects in process Y. An example is the integration of activities in a front-office of an insurance company by giving the front-office employees access to a database containing all related customer data. This can lower the requests for second-line expertise from the back-office. In the right-hand picture 'higher-scope' effects are given: the investment in process X has implications at the level of network Z as well. An example is the shortening of lead-time in process X of activities on the critical path in the network. This both lowers lead-time in X, as well as overall lead-time in Z.

Each effect has its own effect domain. As for objective domains, the general effect domain is defined as the union of all effect domains. The general effect domain should include the general objective domain, because objectives are desired effects.
In some cases, the same effect variable can be used in different effect domains. Take for instance the case of Figure 7.4, where the lead-time of X and the lead-time of Y (or Z) may both be selected as effects. So, the lead-time of X and the lead-time of Y actually express two different effects.

In general, there is no finite upper bound to the general effect domain. In practice, however, the particular interests of those involved in the decision process will set boundaries to it.

7.6 The base case

In CBA always incremental and comparative analyses are used to find the changes caused by an investment (Bierman and Smidt, 1993) and COMET also uses this approach. Yet, effects that occur in the effect domain may not only be caused by the investment, as can be seen in Figure 7.3. The environment constantly changes, which may lead to a ‘vanishing status quo’ for the objective domain (Clemons, 1996). Environmental changes can be caused by a myriad of events, such as changing customer preferences, new competitors in the market, technological developments, etc. The vanishing status quo implies that the objective domain (for instance an organisation) will eventually disappear when no activities are deployed to cope with the environmental changes. To be able to distinguish between the effects caused by the investment and by changing circumstances, we use the base case. The base case represents the ‘without investment’ alternative, which implies a prolongation of the current situation, as pointed out in chapter 3. Where the current situation describes a status quo, the base case describes the objective domain in a changed environment (see Figure 7.5). The base case is used for assessing the opportunity costs when investments are not made and can be used for ‘what-if not’ analyses.

By definition, COMET incorporates the base case in any investment decision to support the incremental analysis approach (see chapters 9-11).
The objective setting module

The objective setting module (OS module) supports the objective setting stage of the decision process. Its primary goal is to set the objectives of the telematics investment in terms of desirable investment effects to be achieved.

8.1 Inputs, outputs and steps within the OS module

The OS module and its inputs and outputs are given in Figure 8.1. This section describes in general the inputs for this module, the results which it should deliver and the steps to be taken within this module. Sections 8.2 and 8.3 will more in-depth present the steps in the module and the support which is available.

Figure 8.1 The objective setting module and its inputs and outputs

Input

Inputs for objective setting in the coarse cycles are general business strategies and information on developments in the environment, as well as
results from previous cycles. For fine cycles the inputs are formed by results of previous cycles, in particular the generated alternatives (see chapter 9).

**Output**
The OS module should render objectives. The objectives describe a desired state of the new situation (for instance, the preferred role the organisation wants to have in a logistics chain) and a statement about the performance of the new situation (for instance a lead-time improvement of 10% compared to the current situation). The desired state can be used as starting point for the development of alternatives. Alternatives assessment focuses on the performance.

The investments should (eventually) lead to new situation. The objectives should be described in such a way that proper assessment of the contribution of an investment can be performed. Therefore, the objectives rendered by this module should consist of a variable, an aspiration level for this variable and the associated objective domain. We will use the term decision criterion to refer to the variable and target to refer to the aspiration level. Besides the objectives, this module can be used to generate additional criteria. These criteria allow for assessment of aspects not covered by the objectives. Their addition is used to gain more complete insight into the consequences of the investment.

**Steps in the OS module**
The objectives are leading for alternative generation and are the norm with which the alternative assessment results are matched in the choice module (see Figure 8.2). Therefore, the OS module contains a step called determination of objectives. In order to come to a relevant objective, the organisation(s) under consideration should be investigated, in their present state as well as from the perspective of possible future developments in- or outside the organisation (Porter, 1985; Van der Heijden, 1996). This may be done in a SWOT and scenario analysis step. The result of this step is a set of strengths, weaknesses, opportunities and threats, in short, SWOT. The SWOT are used as input for the determination of objectives.

Note that other approaches for objective setting are possible as well (see for example Briston and Liversidge, 1979; Butler *et al.* 1993; Robson, 1997).
8.2 **Scenario and SWOT analysis**

Figure 8.3 is the part of Figure 8.1 dealing with the scenario and SWOT analysis step.
Input
In order to come in the first decision cycle to a set of SWOT, factual information about the unit of analysis (such as organisational (network) structure, processes, resources, and people) is needed (Robson, 1997). Next to that, factual and tentative information on developments outside the unit of analysis is necessary.

Information on developments in the environment can be obtained from numerous sources, such as branch organisations, statistics, newspapers, television, conferences, (own) market inquiries, etc. According to Lynch and Cross (1995) the focus of analysis of the external environment should be on the customer needs, technological advances (telematics opportunities) and competition. They suggest decision-makers to ask questions like:
- Who are our customers? What are they looking for today, and how are we satisfying their needs?
- What is the technology in the industry today and how is it changing? What will our technological need be in the (near) future and how will this affect the way we do business?
- Who are our competitors? How are we positioned and perceived in the marketplace? What are our competitors doing and where are they going?

These questions should be asked for the unit of analysis. As given, the unit can be an organisation, organisational chain or network. Hence, the analysis should have the scope of the unit. At chain and network level, this requires co-operation between organisation in analysing the environment.

Output
This step results in a number of strengths, weaknesses, opportunities and threats for the objective domain, conform the common meaning of these terms in SWOT analysis (see chapter 5).

Methods
In order to set objectives, the decision-makers must analyse the unit of analysis and developments in its environment. This should be an analysis of the current situation and possible future situations. Common and frequently used approaches are scenario planning (see Clemons, 1995, Schoemaker, 1995 and Van der Heijden, 1996) and SWOT analysis (see Robson, 1997). The strengths and weaknesses are based on a SWOT analysis of the current state of the objective domain. For the opportunities and threats, next to an analysis of the unit’s environment, an exploratory analysis of possible and plausible future external developments is needed. Therefore, scenario analysis is used. Scenarios offer the opportunity to present discontinuities in environmental developments, making it possible
to analyse the consequences for the strategy to be pursued for the unit of analysis: is it robust enough or should it be adapted to changing circumstances. A clear vision on the S and W aspects of the unit of analysis and the current and future O and T aspects of the unit’s environment supports pro-active decision-making.

In the SWOT analysis, a decision-maker may use the five forces model in combination with the value chain and value system model of Porter (1980, 1985). These models offer a comprehensive view on the organisations and their transactional environments (that part of the environment in which the organisations are an important player and mutual influence of organisations and playing field exists). They are complementary; the five forces model mainly supports analysis of the environment, whereas the value chain and value system model mainly supports internal analysis of an organisation or chain. The models are simple in use compared to other methods for this activity (see chapter 5).

Figure 8.4 is an elaboration of Figure 8.1 and summarises the structure of this step.

In Figure 8.4, two major activities are presented:
- The scenario analysis. This analysis needs inputs on environmental trends. The step can be supported by scenario planning techniques. Its
result should be a set of different scenarios which serves as input for the determination of future opportunities and threats for the unit of analysis.

- The SWOT analysis. The SWOT analysis consists of three components: an analysis of the unit under consideration, its current environment and its probable future environment. The analysis makes use of inputs from the objective domain, the current environment and the scenarios. Support may come from Porter’s models and this activity should render a SWOT.

The SWOT and scenario analysis will be performed in the coarse cycle groups and their results may be refined in consecutive coarse cycles. The analyses form the basis for the objectives, which in the coarse cycles should be determined and may be amended, discarded and refined. The objectives will return in the fine cycles were they can be refined.

Within the objective setting stage, TG decided to develop two scenarios which they named globetrotter and service seeker. These scenarios, along the lines of types of customers, can be seen as two possible futures for the organisation.

The construction of the scenarios was realised in three steps: first, a small group of experts from management, marketing and IT had a brainstorm session of half a day, supported by a group decision instrument (GDI, a set of linked PCs). Input for this session was information from the travel market and the IT market. In a second step, the results were condensed in a number of statements on future developments. The third step consisted of two parallel expert sessions, both in which the experts related the statements in such a fashion that a running story on the future evolved. The results of these two sessions were seen as the scenarios. Several future trends were foreseen in both scenarios:

- A slow, but clear, disappearance of the differences between the tourist travel market and the business travel market, leading in both markets to the demand for the same products and services.
- A shift in revenue generation: the airlines no longer pay TG a fee for every ticket sold, but the customer pays for value added services which TG will have to offer.
- The market hardly grows and an increase in concentration of suppliers and competitors through mergers and take-overs takes place.

In addition to these trends, the globetrotter scenario described a future in which the customer constructs his own travel package. TG must offer travel components (like airline reservations, hotels, car rentals) to this customer. This customer is very cost-conscious and will easily decide to just buy a minimum set of travel components and then decide at his destiny what to do next. He may go to another (local) travel organisation or seek additions for his travel via the Internet. Travel package construction and reservation via the Internet has become common as a new and major distribution channel next to the traditional travel shops.

In the service seeker scenario two groups were defined: the travellers with much money and little time and the travellers with much time and little money. Both demand hassle-free travelling and TG should arrange the complete door-to-door trip and customer service is key in this scenario. Here, TG should offer complete packages of travel components which should be tailored to the customer and allow smooth travelling.
On top of this, the much money-little time customer should preferably be provided with real-time and on-line information on his trip.

Except for the disappearance of the differences between the tourist and business travel market, the general trends in both scenarios were seen as future threats:
- A forced shift from fee-based production to value-added based production.
- Hardly or no growth of the travel market combined with an increase in concentration of suppliers and competitors.

The globetrotter scenario rendered the following future opportunities and threats:
- Possibilities of airline reservation via the Internet and possibilities to offer world-wide service to the customer via the Internet.
- Customers more and more determine their own travel product and have a need for the advisory function of the travel organisation.
- The cost-conscious traveller is not willing to pay (much) for the advisory function of TG.

The service seeker scenario rendered the following future opportunities and threats:
- The demand for complete travel packages offers the possibility to focus on the value added services approach, which is triggered by the shift in revenue generation.
- TG can distinct itself from its competitors by offering unique travel packages.
- TG must be capable to instantaneously offer information to the traveller during his trip, wherever the traveller will be.

In parallel to the scenario development, TG performed a SWOT-analysis using Porter's models. By systematically analysing the relations with the environment by using the five-forces framework, the following current opportunities and threats were derived (some of the opportunities and threats were also recognised in scenarios as future trends):
- Tourists more and more determine their own travel product and have a need for the advisory function of the travel organisation.
- The product assortment is broadening.
- The business traveller demands full service at a global scale.
- Unification of the European market, allowing for further expansion.
- Hardly or no growth of the travel market combined with an increase in concentration of suppliers and competitors.
- The IATA guidelines as a hindrance in the use of new technology.

TG performed an analysis of the organisation by using the value-chain model. First, all value creating and supporting activities were determined. Next, each of them was analysed. The main value creating activity is the sales process in the travel shops. The analysis revealed the following strengths and weaknesses:
- Productivity in terms of trips sold is low and TG does not perform better than other travel organisations.
- There is no relation between the business travel shops and the tourist travel shops, hampering the possibility of cross-selling products.
- Due to growth of TG, a continuous inflow of new people is guaranteed, with new fresh ideas to improve productivity.

The two main supporting activities are management of the organisation and IT management. Strengths and weaknesses of TG's management are:
- A clear picture of its own future and a good view at market developments.
- A reputation of creating innovative ideas.
- Lack of good project management.
Strengths and weaknesses of TG's IT management are:

- A good view at IT-market developments and know-how to translate this into solutions for TG.
- Lack of good project management of telematics projects.
- Many local IT solutions and no proper integrated telematics infrastructure for the entire organisation.

8.3 Determination of objectives and decision criteria

The next activity in this module is the determination of the investment objectives and the associated decision criteria. This step is the core of the OS module. It serves to bring about investment objectives and a list of decision criteria. Figure 8.5 shows the corresponding excerpt from Figure 8.1.

**Input**

Determination of objectives and decision criteria will be performed in every COMET cycle group. Differences between the cycle groups stem from adjustment of the objectives based on the sieve and magnifying glass mechanisms (see chapter 7).

For the coarse cycle group, results of the scenario and SWOT analyses and the general business strategies are necessary. The business strategies should point out where the organisation aims at in the short, medium and the long term. Insight into these strategies is necessary because the telematics objectives and investments should be in alignment with them.

For the fine cycles, inputs of this activity will be the results from previous decision cycles.

**Outputs**

The output of this step is a set of objectives which are made operational by means of decision criteria (i.e. means to assess the alternatives). An objective has three components:

- The *objective domain* (see chapter 7).
- The decision criterion, that is, the property that is subject to wishes of the decision-maker.
- The objective target, which typically is:
  - The desired value of the objective variable for the objective domain,
  - A minimum or maximum value (or both), or
  - A mere value direction, for example: as high as possible.

Decision-makers may also decide to define additional criteria as a means to assess consequences of an investment outside the objective domain. An additional criterion is like an objective, but its domain is different.

**Methods in the coarse cycles**

On the basis of the SWOT and the general business strategies, the decision-makers should determine investment objectives. By confronting the SWOT with the business strategies the decision-makers should determine (Robson, 1997):
- For a strength, how to strengthen or consolidate it.
- For a weakness how to improve it.
- For an opportunity how to exploit it.
- For a threat, how to avoid or anticipate it.

To assess the contribution of an investment alternative to the objectives, decision-makers should choose a proper set of decision criteria. For the support of deriving these decision criteria, COMET offers a decision criteria checklist, based on the Balanced Scorecard (BSC), which we described in chapter 5. This list of criteria suggested in COMET is neither complete nor definite; it is rather a set of example criteria than a fixed list. However, by using the BSC perspectives, a complete view on investment consequences for the unit of analysis can be obtained. Of course, decision-makers should determine the relevant criteria for the specific situation for which the objective is established. They may use the above mentioned criteria as a starting point in the coarse cycle group.

Many methods have been put forward to gain more complete insight into organisational performance and the impact of investment projects on the organisation. An example of a structured approach to express organisational objectives in decision criteria is BSC (Kaplan and Norton, 1996b). BSC offers four perspectives: financial, customer-related, learning- and growth-related and internal business process-related. The dimensions form a hierarchy, in which the financial perspective is the top level, to which the other perspectives contribute (see for a more extensive description chapter 5). The perspectives offer a comprehensive view on the organisation and we therefore take them as a starting point for the criteria.

In the decision criteria checklist, each perspective should be covered by at least one decision criterion. Following the hierarchy in the BSC, we have
a financial criterion at the top level. Decision-makers should use *Net Present Value* (NPV) as the decision criterion to express financial consequences of the telematics investment.

![Figure 8.6 Forms in which criteria can be expressed](image.png)

Yet, not all effects can be expressed in financial terms without loss of information and without an increase of uncertainty (Figure 8.6). In their study, Willcocks and Lester (1996) conclude that most organisations use more than one decision criterion. Basis of all combinations is CBA. In most cases studied, it was combined with competitive advantage. Other combinations were CBA with either service to the public, quality of product, job enhancement, improved management information, user requirements, legal requirements or strategic importance. Their study also revealed that organisations may be missing telematics opportunities, or taking large risks, by using approaches that do not clarify and assess less tangible inputs and benefits (Willcocks and Lester, 1996). COMET therefore includes a number of non-financial criteria in its checklist and takes a multi-criteria approach.

<table>
<thead>
<tr>
<th>Balanced Scorecard</th>
<th>COMET</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope:</strong> single organisation</td>
<td>scope: process, organisation, network</td>
</tr>
<tr>
<td><strong>aim:</strong> ex-post performance measure</td>
<td>aim: ex-ante investment decision support</td>
</tr>
<tr>
<td>Financial perspective (including risk)</td>
<td>Net Present Value + option theory</td>
</tr>
<tr>
<td>Customer perspective</td>
<td>Customer service</td>
</tr>
<tr>
<td>Internal business process perspective</td>
<td>Efficiency</td>
</tr>
<tr>
<td>Learning and growth perspective</td>
<td>Employee well-being, Agility</td>
</tr>
<tr>
<td></td>
<td>Migration costs</td>
</tr>
</tbody>
</table>

Table 8.1 introduces the COMET criteria for the BSC perspectives. The table also indicates the differences between BSC and COMET. The combination of criteria, as given in the right-hand side of Table 8.1, is the decision criteria checklist. Where the BSC perspectives all refer to the new situation, the migration costs in the table refer to the *transition* from the current situation into the new situation. Hence, this is an addition to the BSC perspectives. As can be seen from the table, often suggested criteria, like flexibility, quality and lead-time (see Lynch and Cross, 1995; Kaplan and Norton,
1996b) are not used. In chapters 9 and 10 we will show how decision-makers can take scores on these variables into account.

As already indicated, the financial perspective is covered by the NPV. We choose NPV because it considers the time value of money.

In their performance pyramid, Lynch and Cross (1995) distinguish an internal and external dimension that respectively focus on improvement of efficiency and effectiveness. By taking this as a reference, we suggest to use efficiency as a criterion to cover the internal business process perspective. Efficiency is a measure for the amount and combination of resources used to produce a certain amount of products (in short: resources divided by outputs). Efficiency aims at ‘doing the thing right’ (cf. Kleijnen, 1980). In the context of the performance pyramid effectiveness expresses how well customer needs are satisfied (‘doing the right thing’, cf. Kleijnen, 1980). The activities that aim at satisfying the customer can be covered by customer service. We suggest this criterion to cover the customer perspective. Customer service is the combination of processes and products exchanged at the unit’s border which satisfy the unit’s customers. While the introduction of telematics can range from local processes to entire business networks, the ‘customer’ can be another process, another organisation, or the end-customer of the network.

The learning and growth perspective focuses on those aspects of the unit of analysis which determine future success. Kaplan and Norton (1996b) distinguish three categories for this perspective:
- Employee capabilities.
- Information system capabilities.
- Motivation, empowerment and alignment.

The first and last group recognise the importance of the employee for future success. By making the employee central to the success, his well-being should be guaranteed, while this directly influences his productivity and ability to learn. We therefore suggest to use employee well-being as criterion. We expect that information system capabilities alone are not sufficient for the unit of analysis to be successful in the future. The unit of analysis should be ready and capable to quickly adapt to changing circumstances. We suggest to use agility as a criterion to cover this part of the learning and growth perspective. Agility is the adaptability of a unit to meet changing environments in the future. Agility is suggested because telematics severely influences (enables) the unit’s possibilities to adapt to changing circumstances. In literature various other definitions are used: Metes et al. (1998) see it is an enterprise-wide strategy in which the customer is the first priority, change is an opportunity to do things better, and delivering value has top priority. Goldman et al. (1995) define an agile company as one which is capable of operating profitably in a competitive
environment of continually, and unpredictably, changing customer opportunities. Preis (1997) defines agility as quickly responding to the challenge of incessant change. The Council of Logistics Management (CLM, 1995) defines it as the competency of achieving and retaining customer success and competitiveness. In the descriptions and definitions the constant environmental changes and the capability to quickly respond to these changes is apparent, which is also covered by our definition.

The above mentioned criteria all refer to a single alternative. To clarify which effects occur during the transition from the current situation into that alternative situation, we use migration costs. Large portions of migration costs can often be expressed in financial terms.

We elaborate on the decision criteria in chapter 9.

Additional criteria

As stated, every objective gives rise to a decision criterion. Next to that, however, decision-makers may use additional decision criteria. For example, decision-makers may be interested in a certain decision criterion without including it as an objective.

Notice that there may be more than one objective with the same objective variable, when only the domains differ. For example: the NPV of the entire chain of organisations must be as high as possible, but no NPV of a single organisation in the chain may be negative. In another case, the NPV of the entire chain may be used as an objective, whereas the individual NPVs are just additional criteria.

Methods in the fine cycles

In the fine cycles, the objectives and decision criteria are based on those of the previous cycles. In fact, they may be copied without changes in the new cycles. But, they can also be changed, augmented, enhanced, dropped, or refined, typically based on the assessment results of the previous stage. For instance, when assessment in the previous cycle has shown that no alternative meets a certain objective, this objective may be loosened by changing the target. It is also possible to add any new objective or additional criterion originating from whichever source.

Running example: TG's objectives and additional criteria

Although not explicitly described in a strategy document, TG's management reports to have a clear view on the strategy: the general business strategy of TG is to become number 1 in the business market and grow substantial in the tourist market. Combining this with the results of the SWOT, TG recognises the importance of new technology to reach those objectives. The objective is to invest in state of the art telematics in order to prepare the organisation for the future. TG's management recognises the fact that the investment programme not only contains investments in IT, but also a large organisational component.
Stated criteria are cutting back the administrative time by 50% at the tourism travel shops and an improvement in administrative efficiency of 25-40% at the business travel shops. A restriction to the investment is a tight payback period of two years. More implicit criteria are improvement of customer service and agility. Employee-related criteria are not mentioned (except for training needs, which will be reflected by migration costs).

In summary:
- Strategy: become number 1 in the business market; grow substantially in the tourist market
- Objective 1: cutting back administrative time by 50% at the tourism travel shops
  
  **Criterion: efficiency**
  
  **Target:** decrease lead-time by 50%
  
  **Domain:** administrative processes at the tourist travel shops
- Objective 2: improving administrative efficiency of 25-40% at the business travel shops
  
  **Criterion: efficiency**
  
  **Target:** efficiency improvement by 25-40%
  
  **Domain:** administrative processes at the business travel shops
- additional criterion: agility, target: enlarge, domain: entire organisation
- additional criterion: customer service, target: 60%, domain: interface with customer
- additional criterion: employee well-being, target: sustain, domain: entire organisation
The alternatives generation module

The next stage in the decision making process is generation of alternatives. The alternatives generation module (AG module) supports this step. The goal is to develop alternatives which satisfy the objectives set in the previous module.

9.1 Inputs, outputs and steps within the AG module

Figure 9.1 presents the AG module and its inputs and outputs. The current section describes in general the inputs for the AG module, the results which it should deliver and the steps to be taken. Sections 9.2-9.4 will present the steps in the module and the support which is available in more depth.

Input

For the first coarse cycle, the inputs are formed by the results of the objective setting module, which are the objectives and additional criteria. In the next coarse cycles, as well as in the fine cycles, inputs stem from the objective setting module, complemented with results from previous cycles, notably earlier future investment maps and earlier effects.
Output
The first result of this module is a future investment map (FIM), a structure in which investment alternatives and their relations are represented. We elaborate on the FIM in section 9.2. The second result is a list of effects. In assessing the full impact of a telematics investment, decision-makers are confronted with the tension between comprehensiveness and manageability of both the process and the results. In COMET we therefore distinguish effects and decision criteria and use a two-stage assessment approach. In this approach, a list of effects is derived from the alternatives. A related result is the set criteria functions, indicating for each criterion its relation with the effects. We elaborate on these latter results in the effect determination step, described in section 9.4.

Figure 9.2 Structure of the AG module

Steps in the AG module
Figure 9.2 presents an overview of the AG module. The first step is the creation of a FIM, which forms the core result of this module. The FIM is
also the input for the second step in this module. In that step, the investment alternatives are classified. The classification of investments is introduced to support the determination of effects that actual implementation of the investment will render. The determination of effects and the way they can relate to the criteria (i.e. the establishment of the criteria functions) is the third step in this module.

9.2 The future investment map

Figure 9.3 is the part of Figure 9.1 which describes the development of the future investment map. The FIM is a structure in which immediate investment alternatives are described along with the possible future investments they enable. We describe it more elaborately after the input and output sections in sections 9.2.1 - 9.2.3.

A major portion of the value of telematics investments accrues from future projects they enable. Often, few benefits are obtained from the initial project (Dos Santos, 1991). Therefore, in order to come to a better appraisal of telematics, future possibilities, enabled by the alternative, should be taken into account (see chapter 1 and Dos Santos, 1991). A clear example is an investment in a network infrastructure, which serves as a 'stepping stone' for investments in applications on top of it. In themselves, these type of investments rarely show positive NPVs (the substantial benefits stem from the investments they enable). Therefore, investments should not be dealt with in isolation, they must be related to investments which can be done in the future on the basis of them. Thus, proper assessment of telematics investments cannot leave future options unconsidered. Alternative generation therefore has to yield more than just the immediate investment alternative at hand.

A way to take the value of future alternatives into account is to make use of concepts developed within option theory (see for this approach chapter.
5). Luchran (1998b) sees possibilities to analyse business proposals as chains of real options. As presented in chapter 5, within option theory, the NPV of a business proposal is determined as: $\text{NPV (entire proposal)} = \text{NPV (alternative under consideration)} + \text{NPV (future alternative(s))}$. This approach makes it possible to financially value a sequence of investments. To make use of option theory concepts, we introduce the future investment map (FIM).

**Input**

In the first coarse cycle the inputs for the FIM development are the results of the OS module, notably the objectives and the additional criteria. In the consecutive coarse cycles and the fine cycles these inputs are added with the earlier developed FIM.

**Outputs**

The result of this step is a future investment map. In the coarse cycles this can be a crude description of alternatives and their relationship.

### 9.2.1 What is a future investment map?

A FIM combines option theory with decision trees. It makes use of the decision tree feature to express alternative investments. In addition, it makes use of option theory features to delay choices and to value series of alternatives (in appendix C we discuss the conceptual differences and resembling features of decision trees, option theory and the FIM). The FIM is a directed graph, in which the nodes are investment alternatives. Arrows between the nodes indicate that one alternative enables the other. The migration costs can be associated with the arrows.

As an example, consider Figure 9.4. The leftmost node (here 0) indicates the current situation (with respect to the unit of analysis). The immediate issue is to decide between investments 1, 2, 3 and B, which are the alternatives. Node B is the base case, indicating a ‘prolongation’ of the current situation (see chapter 7).

Additionally, investment 1 enables investment 4, and later even 6. Investments 1 and 2 both enable investment 5, which enables investment 7, as investment 3 does. In the following we will refer to the alternatives directly or indirectly enabled by the alternatives under consideration as options.
By creating a FIM, decision-makers make explicit which alternatives are under consideration and which future options they enable. Anything that affects the value of the option, affects the value of the alternative too, because the value of the option forms part of the underlying asset value of the alternative (cf. Luehrman, 1998b). The different branches in the FIM represent different investment trajectories of staged investments which can be compared with each other. When a certain alternative is executed, it generates the options, which on their turn, when exercised, generate new options, etc.

Several incoming arrows in a node indicate that their origins are different alternatives. In Figure 9.4, alternative 5 can be reached by either alternative 1 or alternative 2.

If no future options are taken into account, the FIM structure can still be used to support the development and assessment of different solutions for the objective. A FIM will then have a form as given in Figure 9.5. However, by using the FIM in this manner, its benefit of considering options is lost.

**Mutual exclusion**

If implementing any one of a set of investments decreases the value of the other investments, the investments are substitutes (Bierman and Smidt, 1993). In an extreme situation of substitution, undertaking one of the investments may completely eliminate the expected revenues of the other investments. Such investments are said to be mutually exclusive. In other words, mutually exclusive investments are investments adversely affecting the earning possibilities of each other (Bierman and Smidt, 1993). Mutual exclusiveness of alternatives is mainly caused by technical and engineering choices during their development. For example, when a certain computer operating system has to be replaced, decision-makers have the choice from operating systems such as Unix, Windows NT, Novell, Linux, etc. Each of these systems excludes the others based on its technical aspects and at the same time determine the freedom to develop options (certain software
programs will work on a Unix platform and not on a Windows NT platform and vice versa).

A group of mutually exclusive investments will be said to be comparable if the profitability of subsequent investment possibilities will be the same, regardless of which investment is accepted or if all are rejected (Biernan and Smidt, 1993). Investment alternatives should be combined into groups that are both mutually exclusive and comparable before a final decision is made.

We suggest to treat the options within the FIM as being mutually exclusive. Hence, two (or more) arrows leaving from one investment indicate that their destinations are mutual exclusive options. As such, in Figure 9.4, investment 1 enables either investment 4 or investment 5. The main reason to treat options in this manner is that we cannot see from the description of the options beforehand whether their effects will be independent, and hence influence the value of the other options. In other words, due to possible mutual influence, the result of option A + option B may be different from their combination, option (A + B). To cope with this problem, decision-makers who still want to take into account the combination of options, have to introduce this combination as a new option.

We are aware that this may cause extra work in situations where the effects of the different options are independent. As part of future work, research can be performed to make the FIM more intelligent to deal with the differences between dependent and independent options.

**Options versus obligations**
Options are optional. Hence, arrows between nodes in a FIM mean 'may follow', not 'must follow'. Obligatory follow-up investments should be included in the same alternative.

### 9.2.2 Description of nodes

A node within the FIM should describe the unit of analysis in its new setting. The node should therefore contain the business case, describing the organisational and telematics investments. In fact, all aspects of the unit of analysis should be taken into account that are affected by the investment. Typically, these are the processes (such as procurement, sales, marketing, etc.) and their relations, organisational structure, and the resources, in particular people and telematics equipment.

The unit of analysis will also be influenced by factors from the environment. The unit's environment can be divided in the contextual and transactional environment (see Van der Heijden, 1996 and chapter 5). Developments in the transactional environment can be (partly) influenced,
whereas the contextual environment renders situations or issues that are
not under control of the decision-makers. Examples of factors in the
transactional environment are power structures within a chain or network
and willingness to co-operate of (future) partners. Examples of factors in
the contextual environment are technology developments, legal conditions
and societal change.

Developments in both environments should be taken into account
because they can influence the effect values of the alternatives. Decision-
makers can take the relevant external conditions into account for
alternatives of which the effect values are influenced. These external
conditions can, for example, be taken from developed scenarios. While the
different scenarios describe different developments in the external
conditions, it will be necessary in the assessment stage to assess the nodes
(and arrows) for each of the given developments. Another approach is to
determine probabilities on the size of the external conditions and take these
into account during assessment. In fact, this closely resembles the decision-
tree approach to assess alternatives under different states of the
environment (see also Winston, 1994 and appendix C).

Decision-makers should be aware that these approaches will demand
considerable effort: each node (and arrow) has to be assessed for different
circumstances, which actually expands the FIM.

9.2.3 How to build a FIM

How to generate a FIM? Three steps can be recognised: initiating a FIM,
developing a FIM and stopping a FIM.

Initiating a FIM

Inputs for the FIM are the objectives, additional criteria and possibly a
previous FIM. Next to these inputs, ideas/human creativity of decision-
makers (and others) form input for the creation of the FIM. The objectives
describe a desired state of the new situation and/or a statement about the
performance of the new situation. This forms the starting point for the FIM
development. Besides the stated objective, decision-makers also developed
an overall strategy for their organisation. This overall strategy expresses
the vision on the future. In literature, this vision is also referred to as strategic
intent (Hamel and Prahalad, 1989), managerial vision (Nolan and Croson,
1995) or strategic vision (Van der Heijden, 1996) on a desired future
situation. As such, this vision on the future can also serve as starting point
for the FIM development.

From the desired situation, decision-makers can return to the current
situation to analyse which investments have to be taken to come from the
current situation to the future situation. In addition, or in situations where
the future vision is not fully developed yet, decision-makers can start the FIM development by seeking for example situations or benchmarks. Jpelaar (1993) developed lists with example situations which can be used. The lists describe processes and activities, IT possibilities and combinations of the two. The lists describe how specific IT possibilities can be successfully applied within the processes. Of course, these lists should be regularly reviewed in order to keep them up-to-date with the latest telematics developments. The situations represent activities which occur in the organisations and therefore are recognisable for the decision-makers.

**Development of a FIM**

For the development of the FIM, decision-makers can make use investment-dependency rules. Typical rules to be used in further developing a FIM are:

- **Technical/Infrastructure dependency**: applications require basic services and networks. For example, the use of EDI between different organisations at least requires a (third party) network to send the messages. It may also require ‘message handlers’, which can translate the message into organisation-specific formats.

- **Functional dependency**: applications require other applications. For example, real-time transport planning requires a positioning service like GPS.

- **Knowledge dependency**: investments require knowledge or experiences from other investments. Information on successes and failures of other investments may serve to prevent decision-makers from making unnecessary mistakes. By explicitly applying this rule in the FIM development, decision-makers deal with the organisational learning aspect introduced by the BSC. In this sense, this aspect is not an effect which stems from alternatives, but a rule which indicates that knowledge allows for new options within the FIM.

These rules are stated as requirements, so that the FIM develops from right to left, like the desired future situations do. The rules can also be used in reverse, e.g.: ‘Networks enable applications’. In this case, the FIM develops from left to right. Different solutions to fulfil the objectives lead to branches in the FIM, which contain the alternatives and the options.

**Stopping FIM development**

Future alternatives cannot endlessly be taken into account. After the alternatives, there will be an vast amount of new options, which cannot all be assessed.

The level of detail in which the FIM must be developed and the level of extension into the future depend on the added value of these extensions in the assessment and whether a particular extension of the map allows for better assessment of the immediate investment alternatives.
Rules of thumb which can be used to terminate FIM development are:
- Costs of generating new alternatives are becoming too high (for example due to gathering of data).
- The plausibility of results declines (to be determined by the decision-makers).

Running example:
A FIM for TG

The figure at the next page presents the simple future investment map for TG.

As given by the objectives, TG intends to invest in state of the art telematics for the support of efficiency improvement at both the tourist and business travel shops.

As a starting point in the FIM development, TG took the situation of its American sister (TGA), which is ahead in integrating processes within the organisation by means of IT and in developing new products and services. The integration of processes has proven to be successful for the competitive position of TGA and TG's management foresees a similar path. Since TGA is ahead in integrating activities, and both organisations belong to the same holding, integration of activities within TG should lead to alignment with the activities of TGA. In the area of product and services development, TG has more freedom.

To allow for alignment of activities with TGA, several telematics investments are seen as essential: a switch from the current central reservation system (CRS) to a new CRS (which can be the one TGA is using, or a complete new one for both TG and TGA) and a new company-wide telematics infrastructure. The CRS switch will immediately render benefits, whereas benefits from the telematics infrastructure should come from applications which make use of the infrastructure and in which should be invested. TG's IT management decides to combine a possible CRS switch with a possible investment in a new telematics infrastructure in order to present short-term benefits along long-term investments. Two alternatives are developed. The first alternative describes a CRS switch combined with a full implementation of a new telematics infrastructure. Yet, because of the amount of money involved in investing in a new infrastructure, as well as the expected impact to the organisation, the second alternative is the switch from CRS combined with a small infrastructure pilot in a number of travel shops. Besides these alternatives, a base case is developed. Option 4 is a logical consequence of alternative 2. Here, TG's management applies the knowledge dependency rule: first new infrastructure is tested at a small scale, and when successful, the option of full-scale implementation may be chosen.

The alternatives allow for alignment and integration with processes of TGA, but also for new opportunities. Following the approach of TGA, TG also developed options which are possible as a result of a new telematics infrastructure. The infrastructure facilitates electronic communication with the 'outside' world through linkage with the Internet. Two variants are developed: communication with customers via the Internet (option 3) and communication via the Internet with suppliers (option 5). Both for option 3 and 5, infrastructure and functional dependency rules apply.

For alternative 1, the investment domain is the entire organisation, for alternative 2 processes were contacts with suppliers occur (for the CRS) and a group of travel shops (for the pilot) are the investment domain. The investment domain for option 4 is the entire organisation, for option 3 and for alternative 5 the processes where contacts with respectively customers and suppliers occur, i.e. in the travel shops.

TG's management decided to stop the FIM development because of limited human capacity within the decision process for working out more options.
9.3 Telematics investment classification

The next step in the AG module is a classification of the investments described by the alternatives in the FIM. Figure 9.6 is the part of Figure 9.1 which describes the telematics investment classification.

![Figure 9.6 Input and output of the investment classification]

Effects to be assessed should be selected and related to the decision criteria. This is done in the effect determination step (see section 9.4). Selecting effect variables is a complicated issue, because the entire set of possible effects of arbitrary telematics investments is extremely large. Therefore, COMET offers a preparatory step, in which investments under consideration are categorised along dimensions of scope and type of change. According to
their investment class(es), effects can then be more easily identified and selected.

**Input**
The input for this step is the FIM constructed in the previous step.

**Output**
The output of both the coarse and fine cycles is a classification of all investments described in the FIM. This classification, on its turn, is input for determining the effects of investments.

**How to classify investments**
In order to focus on specific investment effects, we opt to supply the decision-maker with a **telematics investment classification scheme (TICS)**. The question now is which dimensions TICS should have.

One option for the scheme would be to use the type of telematics application or technology in the investment. This would require a telematics typology, consisting of entries like EDI, Internet, mobile communication, data mining, and the like. In general however, this has some serious drawbacks:

- First, any telematics typology would fail to stand the swift evolution of telematics technology over time. It would have to be continuously updated on the basis of new technological developments.
- Second, telematics applications cannot be easily separated from each other. Often, investments encompass a range of interacting applications. In fact, telematics applications should even not be isolated from their business environment, since this changes as well (see also chapter 1).
- Third, identical telematics technologies may be deployed at very different organisational levels, thus yielding different effects.

This last drawback suggests another way of classifying telematics investments for our purposes. In this case, the organisational level at which the investment is aimed is an important dimension.

The well-known five-level framework of IT-enabled business transformation of Venkatraman (1991, 1994) supplies a basis for such a classification scheme (see chapter 5 for a description). Below, we investigate the dimensions underlying Venkatraman’s framework. In the following, results of the analysis of the framework are presented.

### 9.3.1 Dimensions in Venkatraman’s framework

**Organisational scope**
The most apparent dimension underlying Venkatraman’s set of levels is that of the organisational scope of the investment. This scope stretches from the individual function or process at the first level to the fifth level, where an
organisation even leaves its previous business environment to enter new markets. Venkatraman’s framework recognises four organisational scopes:
- An *individual business process or function* at the localised exploitation level.
- A *group of processes* at the internal integration and BPR levels.
- An *entire organisation* at the internal integration and BPR levels.
- A *business network* at the business network redesign and business scope redefinition levels.

**Type of change**
The second and the third Venkatraman-level are concerned with groups of processes or the entire organisation. The main difference between these levels is that the type of change at stake is the *integration* between processes within an organisation at level 2, whereas the third level speaks of *redesigning or restructuring* groups of processes or the entire organisation.

The difference between integration and restructuring is that integration of units does not affect the mutual roles of the units; they stay in place, but are aligned or tuned, and are hence enabled by there alignment to function more efficiently or effectively. Restructuring however changes the internal structure, so that units may disappear, new units may appear, or units may be repositioned.

Integration among units by means of telematics mainly aims at information exchange without human intervention. In other words, telematics investments focus on increasing connectivity and ability to share data. In order to accomplish integration, investments can also be focused on creating the conditions under which integration becomes possible. Examples are:
- Information standardisation. Here, the units resort to using the same information formats, semantics and syntax, so that exchange of information will be improved and made easier.
- Enhancing information transparency. Here, units give other units insight into their data(bases), so that, for example, lead-time can be shortened and errors in information exchange can be reduced. Enhancing information transparency is one of the drivers in the development of product data interchange (PDI) and advanced planning systems (APS), where different organisations in a supply chain share their planning.
- Using a common infrastructure. A telematics-infrastructure can be described as a generic and relatively permanent basic facility to support data processing, storage and transport (cf. Van Eekeren and Heinen, 1996). A common infrastructure forms the basis for applications and information exchange of different units. Economies of scale can lower operation costs for each, while the exchange of information can easier flow between the units.
Notice that we use a restricted conception of the word integration. It does not include the merging of roles into new ones. This would be an example of restructuring. Restructuring is a more radical type of change. Yet, restructuring a unit does not affect its role among other units. For instance, restructuring an organisation is not aimed at repositioning it in the marketplace, although serious performance improvement may evolve.

As can be seen, the type-of-change dimension is present in Venkatraman’s framework, but is not independent from the organisational scope. The first as well as the fourth scope level may encompass both the integration and restructuring types from the type-of-change dimension. Toppen et al. (1999), for example, have split the fourth level into business network integration and business network redesign. The fifth level may also be seen as a restructuring of the business world, although a modest one from so large a perspective. The major objective at this level is to identify new business as well as potential threats. Table 9.1 summarises the dimensions in Venkatraman’s framework.

<table>
<thead>
<tr>
<th>Venkatraman-level</th>
<th>Organisational scope</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localised exploitation</td>
<td>Individual process</td>
<td>Integration or restructuring</td>
</tr>
<tr>
<td>Internal integration</td>
<td>Several processes/organisation</td>
<td>Integration</td>
</tr>
<tr>
<td>Business process redesign</td>
<td>Several processes/organisation</td>
<td>Restructuring</td>
</tr>
<tr>
<td>Business network redesign</td>
<td>Business network</td>
<td>Integration or restructuring</td>
</tr>
<tr>
<td>Business scope redefinition</td>
<td>Business network</td>
<td>Integration or restructuring</td>
</tr>
</tbody>
</table>

### 9.3.2 Telematics Investment Classification Scheme

Both investment dimensions of organisational scope and type of change are crucial to the type of effects of the investment, as we will show in section 9.4. Therefore, TICS should be a framework in which the dimensions are independently applied. As to the dimension of organisational scope, it is clear that there is no a priori fixed number of organisational scopes to be set. For example, in an organisation, we may distinguish small individual activities from entire business functions, or even departments or business units. For the sake of discussion however, we will not introduce additional levels in this dimension. Our TICS also contains five levels (see Table 9.2). Yet, the five levels do not immediately correspond to Venkatraman’s.

Venkatraman’s fourth level is split up in two TICS levels: a level concerning the relation between organisations in the network (the network remains the same) and a level concerning the structure of the network (the network changes). Venkatraman’s highest level (business scope redefinition) is located in the fifth level of TICS, because we see it as a change of roles of the organisation, though in another than the current business network.
In the type-of-change dimension we use the division of investments in *structure* and *relation*, instead of the terms restructuring and integration. The former terms are more neutral than the latter ones, since they do not indicate beforehand a direction of change. For example, in the case of relations between units (processes, organisations), the possibility exists that investments are not aimed at *integration*, but at *separation*.

<table>
<thead>
<tr>
<th>Level</th>
<th>Scope of impact</th>
<th>Type of change</th>
<th>What changes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Individual process</td>
<td>Structure</td>
<td>A single process</td>
</tr>
<tr>
<td>2</td>
<td>Individual process</td>
<td>Relation</td>
<td>The interfaces between processes</td>
</tr>
<tr>
<td>3</td>
<td>Several processes/ Organisation</td>
<td>Structure</td>
<td>The organisation’s structure</td>
</tr>
<tr>
<td>4</td>
<td>Organisation</td>
<td>Relation</td>
<td>The interface between organisations</td>
</tr>
<tr>
<td>5</td>
<td>Business network</td>
<td>Structure</td>
<td>The structure of business networks or chains</td>
</tr>
</tbody>
</table>

Figure 9.7 shows where the TICS levels can be positioned in the organisational scope.

It is important to remark that investments may have an impact at more than one TICS level. Typically, for instance, investments aimed at the relation between organisations may ask for their internal structures to be reconsidered. In practice, alternatives will frequently *combine* different types of investments. Therefore, a decision-maker should determine which combination of levels is under consideration in order to find the associated effects.

Within the type-of-change dimension of TICS, the relation and structure investments can be further decomposed into subcategories. This decomposition is given in Figure 9.8.
With these subcategories, decision-makers can focus even more on specific investment effects. Yet, many investments will be combinations of types. In that case, the effects associated with these types must be combined as well.

### 9.3.3 Structure investments

In Figure 9.10 the structure investments are given, as well as their result for the unit of analysis. Except for those aimed at support, structure investments all change the structure of the units.

This decomposition is chosen to emphasise what sort of impacts a structure investment can have on the unit of analysis. Structure investments can be classified in a single category, but will often be a combination of several sub categories. The sub categories are described as follows.

1. **Support.** Support investments aim at facilitating the tasks and thus making performing tasks easier (improve efficiency). The essence of this type of investment is that the unit itself not changes, but its resources do. Examples are CAD-systems replacing drawing boards, word processors replacing typewriters, and all types of administrative systems such as accounting applications and spreadsheets.

2. **Merging of sub-units.** This type of investments is merging of tasks, processes, departments or (parts of) organisations. An example is the
integration of front office and back office tasks in information-intensive organisations, such as banks and insurance companies. Relational databases and data warehouses allow front office employees to perform back office tasks as well, for example within banks checking credit worthiness of customers when they apply for a loan.

3. Separation of sub-units. This type of investments involves separation of tasks, processes, departments or (parts of) organisations. An example is value added logistics (VAL), in which consecutive steps in the production process are separated. This can only be performed with adequate information exchange.

4. Intermediation. This type of investments facilitates the introduction of new tasks, processes or organisations. Examples are new intermediaries within logistics, such as (electronic) information brokers (re-intermediation).

5. Disintermediation. This type of investments involves the deletion of tasks, processes and organisations. Examples are bypassing of forwarders in transport chains and bypassing of travel agencies by airlines and customers through the use of the Internet as a reservation system.

9.3.4 Relation investments

Relation investments leave the unit structure unchanged. In Table 9.3 we present the respective sub categories. The target of the relation investment can either be the product or service exchanged at the unit’s border or the information exchanged to support the relation between the unit and its environment. Relation investments can be aimed at enhancement of exchange, intensification of exchange or replacement of means of exchange.

<table>
<thead>
<tr>
<th>Classification of relation investments.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product or service</strong></td>
</tr>
<tr>
<td>Enhancement</td>
</tr>
<tr>
<td>Intensification</td>
</tr>
<tr>
<td>Replacement</td>
</tr>
</tbody>
</table>

The sub categories are described as follows.

6. New services or products of X. This type of investment either adds features to the current products or services, or constitutes whole new services. Examples are real time tracking and tracing information which transport organisations can add to their existing transport services. Another example is the development of the electronic flower auction (see Van Heck and Ribbers, 1996).

7. Intensifying product exchange. This type of investments involves flexible and quick response to customer requests. Trigger for this type of
investments is the shift in many markets from supply-driven into demand-driven and from mass production into mass customisation and custom-made production. An example is Just-In-Time distribution and production. This requires clear and flawless information exchange. Another example is the lowering of stocks in supermarkets which requires more frequent delivery. This can only be attained by proper information exchange between supermarket, distribution centre and other suppliers.

8. **Intensifying information exchange.** This type of investment aims at more frequent and interactive exchange of information. A trigger for this is the continuous change of production and distribution structures. Examples of concepts developed in the last decades are Value Added Logistics and globalisation, leading to global logistics networks. Furthermore, demand quickly changes and the life cycle of many products decreases. All these changes ask for more frequent and interactive exchange of information. Many telematics products have become available to support this active information exchange. An example is tracking and tracing applications, making communication between the driver and his home base more easily and making it possible to optimise his route in real time.

9. **Communication enhancement.** Investments of this type aim at making the communication richer, quicker and more transparent. E-mail, the Internet and Intranets offer possibilities for interactive communication between the units. Besides, through the Internet, suppliers can communicate with a world-wide pool of potential customers and vice versa.

10. **Substitution of communication.** By this type of investments, one form of communication is replaced by another. This is actually a form of support. Some examples are the replacement of mail by fax, replacement of faxes by EDI, etc. The replacements usually are faster and/or produce fewer errors.

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Running example: Investment classification at TG

To achieve its objectives, TG has worked out the FIM given in the previous section. The initial unit of analysis (organisational scope) is the organisation. The classification is as follows:

- The shift from one CRS to another is a relation type of investment. It combines substitution with enhancement. We classify it as a combination of type 9 and type 10.
- The investment in a new telematics infrastructure is a structure investment. It supports processes and as such is a type 1 investment.
- The investment in a small scale infrastructure pilot is a structure investment. It supports processes and as such is a type 1 investment.
- The investment in Internet communication with customers is a relation type of investment. It is a combination of intensifying and enhancing communication and product exchange, while replacing face-to-face communication with the consumer in the travel shop. As such, it is a combination of type 7, 8, 9 and 10.
- The investment in Internet communication with suppliers is a relation type of investment. The investment allows for enhanced and intensified information exchange between TG and its suppliers. We therefore classify the investment as a combination of type 8 and 9.

As can be seen, investments can be classified in different classes. To determine the associated effects, the different classes per investment will have to be used.

### 9.4 Determination of effects and the criteria functions

Figure 9.11 is the part of Figure 9.1 that concerns effects and criterion function determination. First, we discuss in general the determination of effects and the construction of criteria functions, followed by examples for the decision criteria in the decision criteria checklist (in sections 9.4.1-9.4.6).

![Figure 9.11 Input and output of the effect determination](image)

**Input**
The inputs for effects determination are the categorised investments, the objectives and additional criteria. In both the coarse and fine cycles, effects from the previous cycle may serve as additional inputs.

**Outputs**
The outputs of this step are effects and the relation (function) of the effects with the decision criteria. An effect has two components:
- the effect variable
- the effect domain (see chapter 7)

In the coarse cycles, effects can be altered, amended and refined. The fine cycles may be used to refine effects.
Methods for effect determination
In section 9.3.2 we introduced TICS as a means to classify investment alternatives. TICS classes have been chosen such that distinctive effects can be associated with different classes. Therefore, for effect determination, we suggest a Categorised Effects Framework (CEF), in which combinations of TICS classes and criteria yield a number of effects. These effect should be taken to be part of (associated with) that criterion and of particular relevance to that type of investment. Effect determination then consists in retrieving CEF, using the investment classes and each criterion chosen. Figure 9.12 shows the structure of CEF.

<table>
<thead>
<tr>
<th>Investment type 1</th>
<th>Criterion →</th>
<th>Criterion A</th>
<th>...</th>
<th>Criterion N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects</td>
<td>Effects</td>
<td>Effects</td>
<td>Effects</td>
<td></td>
</tr>
</tbody>
</table>

We will use CEF in sections 9.4.1 - 9.4.6 to give examples of effects which may be chosen as input for the criteria of the decision criteria checklist.

Methods to determine the criteria functions
As given in chapter 7, in COMET we distinguish decision criteria and effects and use a two-stage assessment approach. In this approach, first all effects of the alternatives are investigated and valued after which they are combined in the defined decision criteria. The value of the decision criterion can be seen as a function of the effect values which serve as input:

\[
\text{Value (decision criterion)} = f\{\text{value (effect}_1), \ldots, \text{value (effect}_n)\}
\]

For each criterion this function \( f \) must be determined. In many cases this can be a mere addition of effect values, but more complicated mathematical relations between effects can be chosen.

Here, we mention some typical generic operators that can be used in constructing a criterion function. Many of these are common in multi-criteria analysis (see Janssen, 1991):

- **(linear) Summation.** This operator adds different effect values.
- **Weighing.** By using this operator, the relative importance of the contribution of an effect to the criterion can be expressed. Determining proper weights for each effect can be based on expert's judgement, but will remain a difficult and even arbitrary task.
Norms and boundary values (see Figure 9.13). Norms can be used as (discrete) boundary values within criterion functions. They can have the form of a maximum, minimum or ideal value. The norm can be used for if-then constructions.

For example, if the value for product quality remains under a minimum value, then the entire alternative score is unsatisfactory. Another example is when the value for lead-time is below a maximum, the actual value is taken into account and when it exceeds this maximum, its value becomes infinite, thus rendering a complete other value for the criterion. These are but two examples in which the norms are interpreted as boundary values, several other variants are possible.

Use of a vector of effect values. This operator expresses the criterion value as the combination of effect values. In fact, the effect values are presented ‘as is’ and no operation is performed to combine them into a single value for the criterion. Decision-makers may use this approach when they want to present all information at effect level or are not able to construct a proper relation between the effects and the criterion.

A criterion function can be constructed by combining the above mentioned operators. An example is the Weighted Summation approach, a simple and often used multi-criteria approach in which summation and weighing is combined (see Janssen, 1991). When effects and criteria have the same scale and measurement unit, decision-makers can usually confine to the given operators. Yet, this is often not the case which makes finding a function $f$ which properly combines the effects into the criterion a complicated issue.

First, effects often have different scales. A scale can either be:

- Ratio
- Interval
- Ordinal
- Nominal

Basically, the scale at which a decision criterion will be expressed, can at most be the minimum of all associated effect values. So, if certain effects that serve as input for a decision criterion are expressed at the ratio scale and others at the ordinal scale, the decision criterion has to be expressed at the ordinal scale as well. This leads to a loss of information. Yet, in the structure of COMET, decision-makers first decide on the decision criteria and their expression before estimation. As such, effect values can have a lower scale than the associated criterion. To prevent degradation of the criterion scale, the effect value expressions can be upgraded. This can be done by using the if-then construction as discrete boundary value on other effect values (see Example 9.1).
Example 9.1 Use of cross-effect if-then rule to prevent scale degradation

Suppose the value for customer service is partly determined by the values of the effects availability of information and reliability of information exchange. Reliability of information exchange is expressed at the ratio scale, whereas the availability of information is expressed at the ordinal scale (with the range 'high', 'moderate' and 'low'). This would imply that customer service should be expressed at the ordinal scale as well, whereas decision-makers may want to express it in the form of a percentage, hence at the ratio scale. To allow this expression, decision-makers may incorporate the values for availability of information into the values for reliability of information exchange by using a cross-effect if-then rule. This rule could be applied as follows:
- \( \text{If availability of information is low then minimal reliability of information exchange is } 98\% , \)
- \( \text{if availability of information is moderate then minimal reliability of information exchange is } 96\% , \)
- \( \text{if availability of information is high then minimal reliability of information exchange is } 94\% . \)

These norms and trade-offs should be determined by the decision-makers. In this case, the information from the lower-scale effect availability of information is maintained in the function.

In a next step the results for reliability of information exchange should be combined with values of other effect which serves as input for customer service.

If effect values happen to be expressed at a higher scale than the criterion value, they can be relatively easy downgraded, see Example 9.2.

Example 9.2 Scale downgrading for effects

The effects which serve as input for employee well-being may be expressed at the ratio scale and the ordinal scale. When decision-makers want to express the criterion at the ordinal scale, the effects at the ratio scale may be downgraded (note that information will be lost). This can be done by applying a ordinal expression to a (range) of ratio expressions. For example, the number of responsibilities may be input for employee well-being and has a range from 0 to 30. The approach for downgrading can be:
- When the number is \( \leq 10 \), the ordinal value 'low' is applied,
- when the number is \( > 10 \) and \( \leq 20 \), the ordinal value 'moderate' is applied, and
- when the number is \( > 20 \) and \( \leq 30 \), the ordinal value 'high' is applied.

The ranges and level of refinement may be determined by the decision-makers.

In principle, users of COMET have the freedom to determine which effects belong to what criterion and in what unit the effects and criteria are expressed. For example, decision-makers may use the effect value for lead-time as input for efficiency or as input for customer service. Expression of the value for lead-time can for example be done in time (i.e. lead-time is 2.5 days) or as a percentage (i.e. actual lead-time is 92% of maximal allowed lead-time).

Practical restrictions are formed by the fact that not all expressions can be easily combined. Besides, effect values expressed at a nominal scale are difficult to work with. Examples of effects at the nominal scale are colour (red, green, blue, etc.), shape (round, square, rectangular, etc.) and brand name (i.e. a PC with certain specifications can be obtained from IBM, Dell,
Compaq, HP, etc.). Several steps in the application of effect values at the nominal scale can be taken:
- If the effect value is not relevant, neglect it (relevancy to be determined by the decision-makers),
- If the effects value is relevant, but all alternatives score the same, neglect it,
- If the effect value is relevant and the alternatives score differently, use an if-then construction to express its contribution to the criterion. The result of the criterion will then be a range of values.

Second, even when effects have the same scale, the measurement unit may be different (for instance, amount of apples and amount of pears are ratio-measures, but they cannot simply be added). This problem can be solved by either adapting the function or by adapting the effects. To make the effect values comparable, they must be transformed into a common dimension or into a common dimension-less unit (Janssen, 1991). Within multi-criteria analysis standardisation is a method for this adaptation. By standardising, the dimension of the effects is transformed in such a way that the standardised effects can be compared with each other. Several standardisation procedures are possible (Janssen, 1991):
- scores for each effect can be scaled according to its own score relative to the maximum score;
- the effect score can be scaled according to their relative position between the highest and lowest score;
- vector normalisation;
- division by an ideal or target value.

In the following subsections we describe each criterion from the decision criterion checklist, give examples of effects by confronting it with TICS, and present the components of the criteria function. In chapter 10, the criteria functions will be used in the running example to calculate the criteria values from the effect values.

### 9.4.1 Efficiency

We use the following definition of efficiency: efficiency is resources divided by outputs. All efficiency investments change the degree of resource utilisation, given a certain goal. Changes in efficiency can be attained through:
- Change in resources-use/claim: a change in use of resources by the units. This can either be an increase or decrease in the total amount of resources used or a shift in use form one type of resources to another (for example, manual labour replaced by a machine). Notice that the goal does not change.
- **Economies of scale** occur in a situation in which the average cost of production declines when production capacity and output is increased. It can be seen as a production function in which, when all inputs increase by the same factor, output relatively more increases (adapted from Samuelson and Nordhaus, 1985).
- **Economies of scope**. Economies of scope exist when it is cheaper to produce both good X and Y together than separately (adapted from Samuelson and Nordhaus, 1985).

Efficiency can also be the expression of the resource costs level for a given goal.

**Confrontation with TICS**

For the confrontation of efficiency with TICS we use investment class 5, disintermediation and investment class 10, substitution of communication as examples. Both structure and relation investments lead to changes in resource usage.

Through disintermediation, tasks, processes and even entire organisations may disappear. As an effect, all resource costs of that unit will disappear as well. For example, at the level of a supply chain, organisations that align demand and supply of transport may become redundant, while telematics investments can increase market transparency. This will lead to savings due to disintermediation.

Substitution of communication leads to savings in tasks related to information exchange. For example, the introduction of EDI to replace manual ordering may lead to a change in communication costs, a reduction of the costs of redundant tasks and improved data quality. The redundant tasks can consist of re-entering data, error repair and task switches.

---

Running example:
The efficiency criterion at TG

A stated criterion by TG is the improvement of administrative efficiency of 25-40% at the business travel shops. The investment will change the mixture of resource costs. Effects which can be derived from the investment in:

- The CRS (type 9 and 10): change in communication costs with suppliers
- The telematics infrastructure (type 1): change in infrastructure costs, change in costs of data transformation tasks
- Internet communication with customers (type 7-10): change in communication costs with customers, change in costs of task switches, change in productivity per employee
- Internet communication with suppliers (type 8 and 9): change in communication costs with suppliers, decline in stock (airline tickets) costs, decline of costs of redundant and data transformation tasks

---

**Constructing the efficiency function**

Investments aimed at improving efficiency change the way resources are used. Resources can usually be quantified and often also given a financial
value. Hence, as the changes in use of resources determine the changes in efficiency, the efficiency criterion can be expressed in financial terms. This implies that the value arrived at for efficiency by the alternatives will become a part of the NPV calculation. In that situation efficiency as a separate criterion, next to NPV, disappears during the course of the decision process.

Decision-makers can of course also opt for expressing the efficiency criterion in itself, next to NPV. This can be done by taking resources used as a percentage of the total amount.

9.4.2 Customer service

Customer service is the combination of processes and products exchanged at the unit’s border which satisfy the unit’s customers. The term ‘customer’ is taken in a broad sense. It is the entity to which the unit offers its products. This can be another process within an organisation, another organisation within a chain or network, or the end-customer. Given the description of customer service, it can be broken down into product-related service and process-related service. Typical product-related aspects of customer service are

1. **Product Quality**, which is the consistent conformance of each product to specifications (adapted from Lynch and Cross, 1995).

2. **Product Versatility**, which is the broadness in types of a particular product a unit is able to deliver to its customers (cf. Hoogeweegen, 1997), as well as the service level offered by the unit to its customers. For example, an airline may just offer a seat (as Easy Jet does), whereas others not only arrange a seat, but also take care of ticketing, check-in facilities, lounges, catering, luggage handling, etc.

Versatility can be measured by counting the number of types of a particular product or by the possibility to vary the product dimensions, like size and colour.

Typical process-related aspects of customer service consists are

3. **Lead-time**, which is the time elapsed from the moment customers place an order until the time when they receive the product (Kaplan and Norton, 1996b).

4. **Operational flexibility**, which is the ability to comply with peak requirements to available capacity.

Customer service can be expressed as the number of properly fulfilled customer requests. This can be an absolute number, a number relative to the total number of requests or a number relative to a norm. All forms can be expressed at the ratio scale, the latter two most likely as a percentage.
Confrontation with TICS
For the confrontation of customer service with TICS we use investment class 1, support and investment class 6, new products or services of X as examples.

Support-type of investments will not have a direct relation with customer service. However, by supporting, work may become easier. Telematics applications may take over tasks from humans, probably leading to fewer mistakes and quicker processing. This will have a positive impact on product (information) quality and can decrease overall lead-time. Besides, by taking over tasks of employees which are not related to the interaction with the customer, employees may spend more time on customers, thus allowing for personal attention.

The potential to offer new services extends the product portfolio and hence, positively influences product versatility. For instance, Internet book shops like Amazon.com and Bol.com offer their customers the possibility to buy books without leaving their homes. Not only do they offer an enormous catalogue with millions of titles, they are also able to construct customers profiles, based on purchasing behaviour and customer preferences. This certainly has marketing value for these companies, but it also allows them to present specific tailor-made book-offers and bargains to their customers. This is an additional service, which extends the product versatility of these companies.

The alternatives and options of TG’s FIM have the following customer-service related effects:
- The CRS (type 9 and 10): no direct effects, but probably improved communication with suppliers (airlines), which can decrease overall lead-time
- The telematics infrastructure (type 1): a common platform may decrease all sorts of alignment tasks between sub-units (like data transformation), which can shorten overall lead-time and decrease the number of errors made, thus increasing product quality.
- Internet communication with customers (type 7–10): improved (and perhaps extended information availability), shortened lead-time through quicker information exchange. Increase in operational flexibility through information availability ‘round-the-clock’, without necessary employee intervention
- Internet communication with suppliers (type 8 and 9): no direct effects, but quicker communication with suppliers (airlines), which can decrease overall lead-time

Constructing the customer service function
Customer service is determined by product related components and process related components. Customer service can be expressed as the number of properly fulfilled customer requests. This can be an absolute number, a number relative to the total number of requests or a number relative to a norm. All forms can be expressed at the ratio scale, the latter two most likely as a percentage.
The effects have a positive relationship with customer service (that is, a positive influence on lead-time leads to a decrease in lead-time).

Lead-time can be expressed by a unit of time, like minutes, hours or days. Operational flexibility can be expressed as the additional time to lead-time to fulfil demand when peak requirements occur. Hence, as for lead-time, we can units of time to express operational flexibility.

Sometimes, a single value for customer service is attained by using just one of its components. For instance, the expression of customer service is based on the value for quality, thus indicating the number of acceptable products out of the total number of products (expressed as a percentage). It can also be the percentage of customer requests processed within lead-time constraints, etc. In fact, one of the objectives stated by TG was a reduction in administrative lead-time. The assessment could solely focus upon this effect. When decision-makers choose this approach, information from the other customer service components will be lost. Given the importance of each of the individual components (see for instance Lynch and Cross, 1995; Kaplan and Norton, 1996b), we suggest all components to base the function on. In this manner, decision-makers retain as much information as possible within the decision process.

The decision-makers can also express customer service financially. Changes in customer service values have consequences in customer behaviour, for instance more or less demand. This change in customer behaviour can be given a financial value. Hence, an estimation of the increase or decrease of demand has to be made. Although possible, this is a difficult exercise, while customer behaviour not only depends on changes in customer service. Another approach is to ask customers to value the customer service by using the contingent valuation method (see chapter 3). When decision-makers decide to express the customer service value in financial terms, it becomes part of the NPV.

9.4.3 Employee well-being

Employee well-being is described as the satisfaction with which employees perform their tasks. Two components determine the employee well being (Van der Beek, 1994; Bi and Salvendy, 1994a, b):
1. *Job demand*, which is the capacity and competence required from the employee by his work.
2. *Employee needs and wants fulfilled by his work*, which are the aspects a employee expects from his job. People all have needs and wants that they either need or like to fulfil. A famous classification of the different types of needs and wants is Maslow’s pyramid (1954), which is...
represented in Figure 9.14. The pyramid indicates that humans have a hierarchy in their needs and wants. First the lower level needs have to be fulfilled before humans are able to fulfil the higher level needs. Having a job will contribute to some of the needs and wants of the human being. Given the classification by the pyramid, the needs and wants fulfilled by having a job are in the five higher levels of the pyramid. The application of telematics within processes will influence the way an employee can or should perform his job. As such, it influences whether an employee attains a certain level in the Maslow pyramid and how this level will be attained.

![Maslow pyramid (Maslow, 1954) on page 205]

Effects causing changes in job demand and employee needs are given in Table 9.4 (based on Hockey et al, 1989; Moray et al, 1991; Van der Beek, 1994 and Bi and Salvendy, 1994a,b). The table makes a distinction between qualitative and quantitative effects.

<table>
<thead>
<tr>
<th></th>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job demand</strong></td>
<td>Number of tasks; Number of task switches</td>
<td>Content shifts of tasks</td>
</tr>
<tr>
<td></td>
<td>Task complexity; Task duration; Work pace</td>
<td>Task uncertainty</td>
</tr>
<tr>
<td><strong>Employee needs</strong></td>
<td>Number of responsibilities</td>
<td>Job decision latitude</td>
</tr>
</tbody>
</table>

**Confrontation with TICS**

For the confrontation of customer service with TICS we use investment class 3, separation of sub-units support and investment class 8, intensifying information exchange as examples.

Separation of sub-units implies that both units will operate as distinct entities. As a consequence, changes in job demand may occur, for example the *number and size of tasks* which employees have to fulfil may change. Next to that, the separation of sub-units may also have an impact on the needs and wants of an employee. The *number of responsibilities* and the *employee's job*
**Decision latitude** may change. Decision latitude is the extent of autonomy and opportunities for the worker to improve (or to worsen) the working situation by means of altering the work demands (Van der Beek, 1994). Intensifying information exchange can lead to increased **task complexity** and an increase of the **work pace**. Next to that, the intensification of information exchange may lead to changes in the number of **task switches**. These are the changes an employee must make from one task to another (cf. Moray et al. 1991).

### Running example:
**The employee well-being criterion at TG**

- The CRS (type 9 and 10): an increase in task complexity
- The telematics infrastructure (type 1): a decrease in task duration
- Internet communication with customers (type 7-10): changes in the number of task switches, task duration, work pace and task uncertainty.
- Internet communication with suppliers (type 8 and 9): changes in the number of task switches, task duration, work pace and task uncertainty.

### Constructing the employee well-being function

Since employee well-being is partly determined by employee needs and wants, which usually have a subjective character, expression of this criterion at the ratio and interval scale is not easy. An ordinal scale ranging from low to high through several steps, is more likely to be applied (cf. Kaplan and Norton, 1996b).

The quantitative effects introduced in Table can be counted and given a numerical value. The qualitative values can obtain a qualitative expression like ‘large’, ‘small’, ‘high’, etc.

Several authors have developed (quantitative) models to explain parts of the relation between effects and employee well-being (see for instance the model of Bi and Salvendy to explain process factors affecting human workload, 1994a and 1994b). It can be questioned, however, whether such an extensive exercise delivers enough additional value within the decision making process since the effects values will also be dependent on individual preferences and job type (in other words: perceived effects). For example, some people thrive when having lots of tasks and task switches, whereas others feel better when they have large and clearly defined tasks. This makes employee well-being partly individually determined.

If decision-makers feel the need to express the relative importance of the respective effects for the criterion, the may apply weights.

Another approach to find a value for employee well-being is to let the qualitative and quantitative effect values serve as **indicators**, giving insight into the value of the decision criterion. For each effect, decision-makers can determine directions in which they should go. As such they give an
indication and not an exact value of the criterion. The indicators will rank the alternatives according to the ordinal scale.

Not only the effect values may serve as indicator; decision-makers may also seek for other indicators. For employee well-being, *workload* may be used. It has both a physical and a mental notion. Job demand comprises the quantitative measurable workload, whereas employee needs and wants determine the perceived workload. Another indicator for employee well-being is the *illness-rate* of employees.

The effect values related to employee well-being cannot be properly given a financial value. Decision-makers may use the contingent valuation method to financially value the effects (see chapter 3).

The illness-rate indicator as alternative can be made financial by estimating the costs of unproductive employees.

**9.4.4 Migration costs**

We define migration costs as the costs associated with the transfer of the existing situation into the new situation. By using the term 'costs' we express it at the ratio scale. The two groups of migration costs we recognise are:

1. *Resource transition costs*. These are the costs of the change of the current situation and the costs of the negative impact of the migration on the operations within the current situation (for example through loss of production or sales).
2. *Project costs*. These are the costs of managing and executing the migration.

Note that in terms of capital budgeting, the migration costs form part of the cash flow and as such *cash outlays* instead of costs.

**Confrontation with TICS**

The same migration costs return for all structure and relation-type of investments. They do however vary in size. The following checklists can be used for the resource transition costs and project costs.

The group of resource transition costs comprises (adapted from Hochstrasser, 1994 and Robson, 1997):

- *Hardware*. These are the costs of equipment and necessary facilities.
- *Software*. These are the costs of programs and applications.
- *Specification*. These are the costs of defining the user needs and technical solutions for those needs.
- *Programming*. These are the costs of creating and/or customising the software.
- Modification of legacy systems. These are the costs of adapting the current systems to be able to co-operate with the new systems/applications. An example of a special situation is the necessary adaptation of systems for the year-2000 problem.
- Installation costs. These are the costs of the physical introduction of the new systems (hence, it involves the installation of the hardware, networks and software).
- Training. These are the costs of educating staff in using the new telematics application.
- Outplacement costs. These are the costs of finding other work for employees whose jobs have become redundant by the new investment.
- Decline of current sales. These costs may occur when the introduction of the investment demands too much attention of the employees working in the operational process, or when the new investment does not properly work.

The group of project costs comprises (adapted from Hochstrasser, 1994 and Robson, 1997):
- Labour. These are the costs of the employees working on the introduction of the investment.
- Planning and Control. These are the costs of preparing and managing the investment project.
- Consulting. These are the costs of hired expertise within the project.

Running example:
The migration costs at TG

The alternatives and options of TG’s FIM have the following migration costs:
- The CRS (type 9 and 10): hardware, software, installation, training
- The telematics infrastructure (type 1): hardware, software, specification, installation, labour, planning and control, consulting
- Internet communication with customers (type 7-10): software, programming, training
- Internet communication with suppliers (type 8 and 9): software, programming, training

The costs associated with legacy systems will not be present, while the organisation wants a complete new infrastructure. The costs of outplacement are not foreseen either; TG did not expect a replacement of employees by IT.

Constructing the migration costs function

All above given migration costs can be expressed at the ratio scale and can be given a financial value. The migration costs criterion can be constructed by adding the respective effect values.

When using a financial decision criterion, like the proposed NPV in the decision criteria checklist, migration costs can be used as input for that particular criterion and the migration costs criterion disappears from the checklist.
9.4.5 Agility

We define agility as the adaptability of a unit to meet changing environments in the future. Hence, agility indicates the ability of the unit under consideration to change quickly in an unplanned, unroutine response to changing market opportunities and pressures (Agility Forum, 1998). Assessment of agility therefore requires knowledge on these changes and opportunities. Yet, this knowledge is hardly or not available to decision-makers. Therefore, the decision-maker cannot but reside to an assessment of the agility of a certain alternative on the basis of the alternative itself and its properties. For instance, modularity of processes or products can be taken as an agility effect. This implies that modularity improves agility, irrespective of what might happen in the future. Other agility effects take the same approach. Think of the existence of tight contractual agreements and the use of technology standards in the alternative under consideration. Figure 9.15 depicts the information curtain so typical to agility.

Basically, external circumstances can take on three different forms (cf. Van der Heijden, 1996). They can be an unknownable, for which nothing can be said. They can also take on the form of an external dependency, which allows certain situations to become possible. An example is standardisation. The third form is that of external trigger, which forces the situation to be adapted. An example of an external trigger is legislation. The latter two circumstances are dealt with by the FIM. By being agile, a unit is prepared to cope with unknowables. Because we cannot determine unknowables, we have to rely on the knowledge on the left-hand side of Figure 9.15 and determine what effects of a telematics investment in that situation can be used as input for agility.

Two terms which are often brought in relation with agility are product (or service) versatility and flexibility (see for instance Hoogeweegen, 1997). Note that we introduced these terms as effects in the customer service function.
**Confrontation with TICS**

Agility of the unit of analysis is determined by the structure of the unit and by the inputs, outputs and resources of the unit.

In the structure, the relation of processes with one other is important: a job shop will be more agile than a continuous production line. Therefore, *process modularity* is determining factor for agility. The construction of outputs take the same approach: if a product consists of unique pieces, agility of the unit is low, if however the product is built up from standard components, a unit may more quickly revert to producing other products and/or using other suppliers to deliver the standard components.

Resource and input dependency are other factors that influence agility. A unit may be dependent on the availability of certain technology (standard) or knowledge of employees and may dependent on inputs in terms of quality and availability. In order to ascertain a guaranteed flow of inputs and sales, the unit may have come to contracts with suppliers and customers. Yet, then it is less easy to switch to other suppliers and less easy to cope with changes in demand.

For the confrontation of agility with TICS we use investment class 5, deletion of units support and investment class 10, substitution of communication. When units are deleted, the relation of the unit under consideration with that particular unit will disappear. Examples can be found in supply chains where trade through the Internet allow for a direct relation between supplier and end-customer thereby by-passing intermediaries. The supplier is not dependent on the information of the intermediary any longer and may get rid of contracts with this party, while at the same time can more directly respond to demand.

In substituting communication, one form is replaced by another, most likely more advanced, form of communication. Using more advanced forms of communication increases the technology dependency: in the case of a system breakdown, the impact on the unit is much larger and only very skilled (hence, rare and expensive) experts can solve the problem. The Year-2000 problem illustrates this threat.

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Running example:
The agility criterion at TG

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The alternatives and options of TG's FIM have the following agility related effects:

- The CRS (type 9 and 10): increase in technology dependency, change in contractual obligations
- The telematics infrastructure (type 1): increase in technology dependency, change in process modularity
- Internet communication with customers (type 7-10): increase in technology dependency, change in product modularity
- Internet communication with suppliers (type 8 and 9): increase in technology dependency, change in contractual obligations
Constructing the agility function
The difficulties in handling agility make the ratio and interval scales less suitable for to express this criterion. However, we should be able to express the relative difference between the alternatives. The ordinal scale is suitable for this purpose. We can use a range from low to high in several steps.

The determination of values for agility-related effects is not a simple task. A possible value for process modularity may be found by counting the number of routings a product can make through the process or the number of different products which can be produced by the same process lay-out. Product modularity can be measured by counting the number of different products or product configurations which can be produced by the same set of components.

Contractual obligations can be measured by number and size of contracts. It can also be expressed in costs associated or caused by redeeming or breaking a contract open.

A possible way to measure technology dependency can be expressed by the number of unique and crucial production processes. The higher the number of unique and crucial processes, the higher the technology dependency of the unit.

For the function \( f \) of agility we assume that an increases in process and product modularity will positively influence agility and an increase in contractual obligations and technology dependency will negatively influence agility. If we take the forms of expression given above, agility can be built up from the number of process routings and the number of product configurations less the number of unique and crucial production processes less the number of contracts. The criterion is expressed at the ordinal level and except for contractual obligations, the effects are expressed at the ratio scale. This asks for a downgrading of the effect value scale, where the same approach can be applied as for the employee well-being effects (see for this approach Example 9.2).

To determine the relative importance of each of the values, decision-makers can apply weights to the effects. The combination of effects and applied weights determine the specific function \( f \). When the effects are all scored at the ordinal scale and weights have been applied, decision-makers can add the values into a single figure for agility.

Decision-makers can also use the effect values as indicators giving insight into the value of agility at an ordinal scale. The same applies here as for employee well-being: the effects give an indication and not the exact value.

It is difficult to financially express agility. As for customer service, decision-makers may seek for changes in customer behaviour. Changes in agility have consequences in customer behaviour, for instance, the customer retention
rate may rise. This change in customer behaviour can be given a financial value. The constraints which apply to customer service also apply here: financially valuing customer behaviour is difficult. As for customer service and employee well-being, decision-makers may use the contingent valuation method to financially value the effects (see chapter 3).

When decision-makers decide to express the agility value in financial terms, it becomes part of the NPV.

### 9.4.6 NPV

To express the financial consequences of the telematics investment, we introduced the NPV. The NPV is a special criterion, because it is actually a form of expressing effect values. NPV is expressed at the ratio scale with money as the unit of expression.

The inputs for the NPV are the cash flows from the period under consideration. When the effect values can be expressed in financial terms, they can be added to or subtracted from each other. The cash outlays and inflows mainly stem from the effects determined by the option values, migration costs and efficiency criteria, that is, when these latter effect values are made financial.

**Constructing the NPV function**

For NPV, the function is already given:

\[
NPV = -C_0 + \sum_{j=1}^{i=T} \frac{A_j}{(1 + r)^j}
\]

Besides the effect values as inputs, the NPV also needs the estimated project life and a discount rate.
The alternatives assessment module

Assessment is the next stage in the decision process. With the alternatives assessment module (AA module) of COMET the alternatives in the FIM are assessed.

10.1 Inputs, outputs and steps within the AA module

Figure 10.1 presents the AA module and its inputs and outputs. This section describes in general the inputs for this module, the results which it should deliver and the steps to be taken within this module. Sections 10.2 - 10.4 will present the steps in the module and the support which is available in more depth.

**Input**
Inputs for this module are the FIM, the effects and the criteria functions.

**Output**
The result of this module is a CRITERIA SCORECARD, which contains the criteria values for the alternatives and the base case.
Steps in the AA module

In Figure 10.2 we present the steps to be taken in the AA module. Three main activities need to be performed in this stage of the decision process. First, all effects of each alternative and option should be estimated. In the following step, the effect values of the options should be assigned to the alternatives which make them possible. We call this pull-back. Next, the alternatives should be appraised on the decision criteria. Hence, the effect values associated with the alternatives should be combined into criterion values.

For the assessment activity, two strategies can be followed. The first strategy is
- to estimate all effect values for every single option and alternative,
- then to pull them back into a value for the respective alternatives,
- and next, to appraise the alternatives on the decision criteria.

The second strategy is
- to estimate all effect values for every single option and alternative,
- then to appraise those options and alternatives on the decision criteria,
and next, to pull them back into single appraisal result for the alternatives.

The strategies are presented in Figure 10.3.

```
Assessment strategy 1

Estimate → Pull back → Appraise

Assessment strategy 2

Estimate → Appraise → Pull back
```

The advantage of the first approach over the second is that it is more precise: the appraisal step, in which generally information loss will occur, is postponed to the latest. The advantage of the second strategy over the first is that it is less laborious: only the criterion values, which are less numerous than effect values, are pulled back.

In COMET, we opt for the first strategy. Because every assessment step incorporates a possible loss of information, and hence, makes the results less usable, it is not desirable to worsen this even more. The additional work may be laborious at first, but may be repeated later and possible supported by automated tools. And as a matter of fact, assessment is not a simple task and should not be taken too lightly.

### 10.2 Estimation of effect values

Effect estimation serves to determine the business value of the effects. Figure 10.4 is the part of Figure 10.1 which concerns the estimation of effect values.

```
Future Investment Map → Effects → Estimation of effect values → Complete effects scorecard
```

To perform the estimation of effect values, a number of preparations have been made in previous stages of the decision process.

With the estimation step of the AA module we have to determine the magnitude of the effect values. Determining the size of the effect values is not simple, due to a number of issues which we will address in this section.
Input
The FIM, as well as the effects serve as input for value estimation.

Output
The outputs of this activity are the estimated values of each effect for every alternative and option in the FIM. Together, this is called the COMPLETE EFFECTS SCORECARD. This table can have a form as represented by Table 10.1

<table>
<thead>
<tr>
<th>Alternatives and options →</th>
<th>A1</th>
<th>...</th>
<th>An</th>
<th>O1</th>
<th>...</th>
<th>On</th>
<th>M</th>
<th>...</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect 1</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>...</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Effect n</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

The table gives the effect values (V) for all alternatives (A1…An), all options (O1…On) and all migration costs (MA1-O1…MAN-01, MA1-O2…MAN-1-On, MAN-On).

Methods
Once the effects, their location and their timing have been established, actual estimation of the magnitude can be performed. As presented by Figure 10.5, in the estimation activity all effect values should be estimated for every single node and arrow within the FIM.

Figure 10.5 Estimation of effects for every node and every arrow

The effects relating to the arrows are the migration costs. They have to be taken into account separately from the options, while the FIM recognises that options can be attained via different alternatives, as given in Figure 10.6. It will not be likely that the migration costs from different alternatives
to the same option will be the same. As a consequence, the migration costs cannot be part of the NPV of the option (or we should choose to calculate different option values for the same option, depending on the migration paths towards the option. However, this would lead to several options values, making assessment of the NPV confusing and very complex). The migration can, however, be taken into account when determining the NPV of the alternative.

Estimation of the effect values is an ex-ante activity, i.e. before the effect values actually occur. The issue probably causing most of the difficulties for estimating is uncertainty. Uncertainty is actually a lack of information. Information may be lacking on:

- **The investment itself.** This can be caused by a (too) limited or narrow description of the alternative, which therefore misses the required level of detail for estimation. In this situation, decision-makers may start a new decision cycle to perform the alternatives generation stage in more detail.

- **Environmental conditions.** These environmental conditions are dynamics of the markets in which the organisation is active and which will (partly) determine the size of the effect values. Organisations are involved in many markets: their own sales market, the capital market, the labour market and their supplier markets. Hence, besides the dynamics at their own sales markets, organisations will also face dynamics at each of the other markets, perhaps most notably at the supplier markets from which parts of the investment will come. In particular, prices and configurations of ICT products (hardware, software, services), which comprise a substantial part of the migration costs, are in constant change.

- **The cause-effect relation between investment and the effects.** In an ex-ante situation we will never know for sure which effects will occur despite the fact that we may have very good information on the investment and the environment.

Despite the market dynamics, estimation of a large part of the migration costs may be relatively easy, since they are built up from product prices (for example in the case of hardware and software) and labour costs (for example in the case of consultants fees and training programs). However, the benefits and many other costs cannot simply be derived from market prices, and market prices may change. A problem is that existing support methods for assessment bypass the question how to estimate the effects (see chapter 5). Still, several methods to support the estimation of the size of the values can be used. These methods are represented in Figure 10.7. Each method starts with a data gathering stage (which is solely a supportive step).
Extrapolation of historical data or of analogous initiatives. Here, the decision-makers draw on experience to predict future developments and/or seek for comparable investments performed in the environment (for instance by competitors) of the organisation (or within other business units).

By examining these investments and their effects, decision-makers try to extrapolate the results of these investments into the future (although this is difficult for entirely new investments due to the lack of historical data, as indicated in chapter 1).

For the extrapolation of analogous initiatives, data on the environment are necessary (this can be seen as a form of benchmarking). Forms of data gathering are market research, scanning market prices and interviewing experts or stakeholders such as customers and employees.

A combination of extrapolation and comparison is to scrutinise past initiatives by other organisations. The example situations developed by IJpelaar (1993) can be of use here as a starting point. Both for extrapolation and comparison, the data gathered should be adjusted to the specific situation which the decision-makers are investigating. This is the actual extrapolation.

- Testing (trying/prototyping/laboratory tests). Another approach decision-makers can take is to execute the investment under specific circumstances. For instance, they perform the investment at a small scale, within only a part of the organisation or network. It can also be done in a controlled situation, as in a laboratory test. Decision-makers may also choose for prototyping the new situation. In all these approaches, decision-makers can apply several analysis methods to test the performance of the investment and the robustness of the estimated values. The estimation results of the tests should be translated into real-life. Usually, the tests are performed at a small scale and the results should be scaled up to the planned level of implementation.

- Model-based analysis Decision-makers can also opt to perform a model-based analysis. Hence, the data gathered from the FIM serves as input for building a model of options and alternatives with their respective effects. Many forms of analysis exist. Several analysis methods can be applied for the estimation of effect values and to check robustness of the values:
  - Model checking (functional analysis). Here, the model itself is checked on its explanatory value.
  - Simulation. Based on the focused scenarios, ranges of possible values for the alternatives can be determined by means of simulation tools.
Performance analysis/sensitivity analysis. These analyses are often combined with simulation tools to determine the robustness of the outputs (effect values) of the models.

Decision-makers may note that the quality and/or reliability of the estimated results depends on the fact whether the chosen examples, tests or developed models are representative for the new situation. Hence, some degree of uncertainty remains. This can partly be overcome by performing the estimation more than once or using the same method with different examples or models.

In the following table we present estimated effect values for alternatives 1 and 2 and for the base case.

The first group of effects is associated with efficiency, the second group with customer service, the third with employee well-being, the fourth with migration costs and the fifth with agility. The grey-shaded rows indicate that the alternatives score the same on that particular effect. The effect domain is the company itself and the relation it has with its suppliers.

To estimate the values for the respective effects, TG extrapolated the results of the investments of its sister, TGA. Some major adjustments were made. First, the market situation and expected developments for TG itself had to be taken into account. Hence, instead of the American situation, the Dutch and European situation were important. Important differences are technological advances and differences in regulation (for example, in the area of policy and legislation concerning labour, TG has to comply with the rules of all EU member-states, whereas TGA has to live with one legislator). Second, TGA is much larger than TG. Thus, TG had to 'scale down' the effects. The costs will be lower, as well as economies of scale.

Furthermore, technological advances follow a very rapid pace, so that the situation of TGA may be seen as (recent) history and TG had to foresee new developments.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Communication costs</td>
<td>75.000</td>
<td>80.000</td>
<td>80.000</td>
</tr>
<tr>
<td>Costs of redundant tasks</td>
<td>20.000</td>
<td>5.000</td>
<td>20.000</td>
</tr>
<tr>
<td>Stock costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data transformation costs</td>
<td>50.000</td>
<td>20.000</td>
<td>50.000</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>65.000</td>
<td>55.000</td>
<td>65.000</td>
</tr>
<tr>
<td>2 Reliability of resources</td>
<td>91%</td>
<td>95%</td>
<td>94%</td>
</tr>
<tr>
<td>Reliability of information exchange</td>
<td>94%</td>
<td>95%</td>
<td>98%</td>
</tr>
<tr>
<td>Availability of information</td>
<td>moderate</td>
<td>High</td>
<td>high</td>
</tr>
<tr>
<td>Range of product configurations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead-time</td>
<td>1 hour</td>
<td>40 minutes</td>
<td>50 minutes</td>
</tr>
<tr>
<td>Operational flexibility</td>
<td>1 hour</td>
<td>50 minutes</td>
<td>1 hour</td>
</tr>
<tr>
<td>3 Number of tasks</td>
<td>18</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>(average) Number of task switches</td>
<td>205</td>
<td>140</td>
<td>185</td>
</tr>
<tr>
<td>Content shifts of tasks</td>
<td></td>
<td>Significant</td>
<td>none</td>
</tr>
<tr>
<td>Task complexity</td>
<td>low</td>
<td>Moderate</td>
<td>low</td>
</tr>
<tr>
<td>(average) Task duration</td>
<td>10 minutes</td>
<td>6 minutes</td>
<td>9 minutes</td>
</tr>
</tbody>
</table>
10.3 Assignment of option values to alternatives

Figure 10.8 is the part of Figure 10.1 which concerns the assignment of option values to alternatives.

**Input**

The input for the assignment step is the COMPLETE EFFECTS SCORECARD generated in the previous step.
Output
The output of this step is an effects table in which only the effect values for
the alternatives (i.e. including those of the options) and the base case are
presented. We named this table PULLED-BACK EFFECTS SCORECARD.

Methods
Before we can appraise the alternatives on the decision criteria, the FIM is
traversed backwards (pull-back) to add the effect values of the options to
the effect values of the alternative which renders the options.

Many examples used within option theory limit themselves to one
alternative and one (compound) option, with effects expressed in the same
units at the same scale. However, within the FIM we recognise several
alternatives which all can make several options possible. While the options
are mutually exclusive, we cannot simply add the values of them to the
alternative.

To assign the effect values of the options to those of the alternatives, two
steps have to be taken in iteration:
1. The FIM must be collapsed. This can be done by selecting the effect
   values of a particular option, or by combining the effect values of the options.
2. After the collapse, the FIM must be folded back (from right to left) by adding
   the effect values of the options and the migration costs of the different
   arrows to the effect values of the alternatives.

Figure 10.9 presents the iterative approach of collapsing and folding back
the FIM. Approaches for both steps are given below.

Collapse
When decision-makers use the effect values of a particular option in the
collapsing step, they can use the following rules:
- Maxi-max: assign only the estimates of the option with the best effects.
- Mini-min: assign only the estimates of the option with the worst effects.
- **Mini-max regret**: the regret is measured as the difference between the highest pay-off, given that a particular uncontrollable event occurs, and the pay-off that actually occurs. Next, the maximum regrets are identified and then the minimum of them can be chosen.

- **Maxi-min**: look at the minimum effect values of each option and choose the largest of these.

Application of a particular rule depends on the attitude towards risk of decision-makers. Decision-makers applying the mini-min approach show greater risk aversion than those applying the maxi-max rule.

Running example: Collapsing options through selection within TG’s FIM

TG has to collapse the options 3 (Internet communication with customers) and 5 (Internet communication with suppliers). Here, TG uses the maxi-min rule for collapsing, applied per criterion. A selection of effect values per criterion is given in the table below.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Option 3</th>
<th>Option 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Communication costs</td>
<td>25.000</td>
<td>10.000</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>43.000</td>
<td>50.000</td>
</tr>
<tr>
<td>2 Reliability of resources</td>
<td>95%</td>
<td>94%</td>
</tr>
<tr>
<td>Reliability of information exchange</td>
<td>94%</td>
<td>98%</td>
</tr>
<tr>
<td>3 Number of tasks</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Number of responsibilities</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>5 Process modularity</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Technology dependency</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

For efficiency, TG takes the effect values of option 3 into account. The minimum effect values are 10.000 and 25.000 and applying the maxi-min rule leads to choosing 25.000. Likewise, TG chooses the values of option 3 for employee well-being and agility. For customer service, the application of the rule leads to an indifferent result (the lowest values are 94% for both options). Here, the decision-makers should make a choice.

Note that using the maxi-min rules for collapsing applied to the individual effects lead to combined use of effect values of different options, thus rendering a synthetic result.

The maxi-min rules can only be properly applied when the effect values have the same unit of expression (see for approaches to come to the same unit of expression for effect values chapter 9 and section 10.4). A possibility to overcome this restriction is to apply the rules to a selected set of effect values with the same unit of expression, for instance all financially expressed effect values. An implicit assumption in this approach is that these effects are considered to be more important.

When decision-makers opt for combining the effect values of the options in the vertically collapsing step, they may choose to apply weight factors to the options. The weights can be derived from the likelihood that a particular option will eventually be implemented. In other words, probabilities are
assigned to the options. By using the mini-max rules or applying a zero weight to options, they can be discarded. This can be useful for options with (many) negative effect values, for which it is already clear that they will not be chosen, even before confronting them with the objectives in the choice stage of the decision process.

TG has to collapse the options 3 (Internet communication with customers) and 5 (Internet communication with suppliers). Here, TG uses the combination rule for collapsing. In the table below a selection of effect values is given for each criterion. TG has applied weights to the options. Option 3 obtained a weight of 2 and option 5 a weight of 3.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Option 3</th>
<th>Option 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication costs</td>
<td>25.000</td>
<td>10.000</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>43.000</td>
<td>50.000</td>
</tr>
<tr>
<td>Reliability of resources</td>
<td>95%</td>
<td>94%</td>
</tr>
<tr>
<td>Reliability of information exchange</td>
<td>94%</td>
<td>98%</td>
</tr>
<tr>
<td>Number of tasks</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Number of responsibilities</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Process modularity</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Technology dependency</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

The combination leads to the following effect values:

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication costs</td>
<td>16.000</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>47.200</td>
</tr>
<tr>
<td>Reliability of resources</td>
<td>94.4%</td>
</tr>
<tr>
<td>Reliability of information exchange</td>
<td>96.4%</td>
</tr>
<tr>
<td>Number of tasks</td>
<td>16.4</td>
</tr>
<tr>
<td>Number of responsibilities</td>
<td>6.2</td>
</tr>
<tr>
<td>Process modularity</td>
<td>11</td>
</tr>
<tr>
<td>Technology dependency</td>
<td>4.8</td>
</tr>
</tbody>
</table>

**Fold-back**

Folding back the FIM horizontally can be done by adding the effect values of the options to those of the alternatives. Adding can only be taken literally if effect values are expressed at the ratio scale: effect values of options are added to those of the alternatives. For example, this is the case for financially expressed effect values.

However, this renders inferior results, but, more importantly, many effect values cannot be literally added. Several other methods are used to come to a proper combination of option effect values and the alternative effect values:

- **Discounting.** A common approach in adding future values to current values is to apply a discounting rule. This will be in particular the case
for effect values which are financially expressed (it forms the heart of the NPV-function). When decision-makers apply discounting rules to effects which are not expressed in financial terms, they have to find a proper function which gives insight into the behaviour of that effect value over time.

- **Imposing the option (ignoring the alternative).** In this method, the effect values of the alternative are disregarded and only the future effect values are taken into account. This can be relevant in situations where decision-makers are particularly interested in the future performance. For instance, solely taking into account the future effect values may be relevant for organisations that in several steps want to reorganise or redesign part of their processes in order to better respond to customer requests. Then, the performance of the new situation is what counts, for example in terms of agility and employee-well being. This approach may even allow for a temporary decline in performance, because of the expected increase in future performance.

- **Ignoring the option.** Here, certain future effect values are disregarded. This can be relevant in situations where decision-makers are particularly interested in the current performance of the alternative on a particular decision criterion. For example, an alternative may comprise an investment in an intranet-site to replace internal communication by phone in a bank. The site should allow front-office employees direct access to information available in the back-office. Despite the fact that an intranet-site also gives way for many new options, in this case, decision-makers may be most interested in the direct efficiency gains (or perhaps losses) of the alternative itself. Note that not the entire option is discarded (this would make all work on the FIM useless). The option values of other effects still can be taken into account.

- **Adding functions.** The result of effect estimation may be a function which presents the development of the effect value over time. The functions for the effect of the alternative and the option can be added. Note that disregarding of effects makes the actual estimation of the disregarded effect values redundant. Their presence in the FIM is nevertheless still useful, because of the reusability of the FIM for future investments (see chapter 11).

### 10.4 Appraisal of alternatives on decision criteria

When the option effect values are assigned to the alternatives effect values, the latter effect values can be translated into the decision criteria. Figure 10.10 is the part of Figure 10.1 which concerns the appraisal.
Inputs for this activity
Inputs for this activity are the estimated effect values, in the form of the PULLED-BACK EFFECTS SCORECARD, and the criteria functions (see chapter 9).

Outputs of this activity
The outputs of this activity are appraised alternatives in terms of the decision criteria values. They will be presented in the form of a CRITERIA SCORECARD.

Methods for this activity
In order to judge the alternatives in terms of their values for the respective decision criteria, we need the decision criteria functions. Here we have to apply the functions which are derived in chapter 9, thus yielding the criteria. This will be done in the running example.

The first and fourth group in the PULLED-BACK EFFECTS SCORECARD form input for the determination of the NPV. TG takes a period of 4 years to take results of alternatives and options into account (i.e. $T = 4$ years), and set the discount rate at 17%. The initial investment for alternative 1 is €5,150,000. The range of net cash flows is: 100,000 for year 1, 2,000,000 for year 2, 3,000,000 for year 3 and 3,500,000 for year 4. Applying the NPV formula gives a (rounded) figure of €137,500 for alternative 1. Through applying the same steps to the base case and alternative 2, a result of €60,000 and €70,000 respectively is obtained.

The second group in the PULLED-BACK EFFECTS SCORECARD form the input for customer service (which is an additional criterion). Except for availability of information, all effects associated with customer service are expressed at the ratio scale, as is customer service itself. To prevent scale degradation, TG uses a cross-effect if-then construction between availability of information and reliability of information exchange. In other words, the values for availability of information determine the norms, i.e. boundary values for reliability of information exchange. An example of a construction can be: if availability of information is low then minimal reliability of information exchange is 98%, if availability of information is moderate then minimal reliability of information exchange is 96%, and if availability of information is high then minimal reliability of information exchange is 94%. These norms and trade-offs are determined by the decision-makers on the basis of the situation of TGA. They can seek for other relations between effects as well. When applying this rule to the scorecard, we see that:
- availability of information in the base case is low; minimal reliability is 98%; the base case scores 91%, which is insufficient
- availability of information in alternatives 1 and 2 is high; minimal reliability is 94%; alternative 1 scores 95% and alternative 2 94%, which is sufficient, given the minimal reliability requirement of 94%

On the basis of this result, TG may decide to neglect the base case, while it already turns out to be insufficient.

Customer service is given as a percentage, whereas lead-time and operational flexibility are given in time. These latter two can be expressed as a percentage when a target time is introduced. The target can be a certain difference with the base case. A stated goal by TG was a decrease in administrative lead-time by 50%. Alternative 1 renders a decrease in lead-time of 33%, whereas alternative 2 renders a decrease in lead-time of 17%. Changes in operational flexibility are 17% and 0%, respectively.

In the scorecard, the range of product configurations has obtained the same value for all alternatives. TG may therefore decide not to take them into consideration. However, if they do, a translation into a percentage should be made as well. This can be done by comparing the actual range with a potential, or ideal range.

When all effects are expressed as percentages, decision-makers may use an averaging rule to express the customer service value. They may also decide to use weights to take the relative importance of the effects to the criterion into account. Since lead-time was seen as very important, weights are applied to emphasise lead-time. Lead-time is given a weight of 0.5, operational flexibility of 0.2, reliability of resources 0.15 and reliability of information exchange also 0.15. The results for alternatives 1 and 2 are 48.4% and 37.3%. The result of the base case is insufficient.

The third group in the PULLED-BACK EFFECTS SCORECARD form the input for employee well-being (which is an additional criterion). Task uncertainty is the same for each alternative and decision-makers may therefore decide not to take this effect into account. The content shift of tasks is expressed at the ordinal scale, but in different units of expression. This calls for a translation from these units into the units of the criterion by standardising it. If the unit of expression has a range of 3, a translation is rather straightforward, since this is the range we also use for the other effects and the criterion. If the unit has another range, it must be mapped on the range of 3.

Effects expressed at the ratio scales need to be downgraded by introducing ranges to which an ordinal expression can be applied. For each effect, decision-makers should determine the direction, i.e. whether a high score for an effect is positive or negative. TG determined the following directions for the employee well-being effects:
- a larger number of tasks is positive
- a larger number of task switches is negative
- a higher content shift in tasks is positive
- a higher complexity of tasks is positive
- a higher task duration is negative
- a higher work pace is negative
- a higher task uncertainty is negative
- a higher number of responsibilities is positive
- an increase in decision latitude is positive
Applying this to the scorecard can deliver a table like the one below:

<table>
<thead>
<tr>
<th>Effect</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tasks</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>(average) Number of task switches</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Content shifts of tasks</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Task complexity</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>(average) Task duration</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Work pace</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Task uncertainty</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Number of responsibilities</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Decision latitude</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

In order to get the ordinal effect values into the ordinal criterion value, an intermediate calculation step can be performed by first giving the ordinal values a number (and, if desired, a weight) and then calculating the average, which will be the result for the criterion.

The resulting table is given below. By averaging, the base case scores 1.44, alternative 1 scores 2.11 and alternative 2 scores 1.66. These scores are translated back into 'low' for the base case and 'moderate' for both alternatives.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tasks</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(average) Number of task switches</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Content shifts of tasks</td>
<td>-</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Task complexity</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>(average) Task duration</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Work pace</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Task uncertainty</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of responsibilities</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Decision latitude</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

The fifth group in the PULLED-BACK EFFECTS SCORECARD form the input for agility. TG uses the same approach here as for employee well-being. Hence, effects at expressed at the ratio scales need to be downgraded by introducing ranges to which an ordinal expression can be applied. Then, the intermediate calculation step can be made, rendering values for agility criterion. Applying this approach lead to a value of 1.75 for the base case and alternative 2 and a value of 2.5 for alternative 1. These scores are translated back into 'moderate' for the base case and alternative 2 and 'high' for alternative 1.

Application of the function translates the values from the PULLED-BACK EFFECTS SCORECARD into the values of the CRITERIA SCORECARD, as presented in the table below. This scorecard forms input for the choice module.
Running example:

**CRITERIA SCORECARD** presenting non-weighed criteria values for the alternatives at TG. The effect values of the options which contribute to the alternatives are added to them, after which a translation of effect values into criteria values is made.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV + option values</td>
<td>60.000</td>
<td>137.500</td>
<td>70.000</td>
</tr>
<tr>
<td>Customer service</td>
<td>Insufficient</td>
<td>48.4%</td>
<td>37.3%</td>
</tr>
<tr>
<td>Employee well being</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Agility</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

### 10.5 A note on risk

Several types of risk are associated with implementing an alternative. First, implementation may fail and lead to different results than projected. Second, implementation may follow deviating paths to the end-result, thus generally increasing migration costs. Third, the result situation may turn out to be unreliable or unstable and immediately migrate into another situation, also unforeseen. We call these *implementation risks* and depicted them in Figure 10.11. Other risks are concerned with the insecurity of estimating effects and estimating future environmental variables.

![Figure 10.11: Risk of a different migration path (m'), an unstable situation (1 shifts into 1') and risk of attaining a different situation (1'')](image)

It is common practice to assess risk, but before assessing, decision-makers should be clear about their attitude toward risk. This will for a large part determine whether a certain risk level is acceptable or not. In option theory and NPV adjustments for risk are often made by raising the discount rate with a proper risk premium. By doing so, the sources of risk are incorporated into the financial value of the alternatives.

However, if the risk in question relates to the costs, it would be expected to *add* to the costs and not *subtract* from it, which occurs by using a risk premium. Luehrman (1998a) points out that the risk premium should be differentiated for the incomes and outflows. A risk premium on the discount rate not only lowers the future inflows, which is the intention, but also the expenses. If a premium is added to the discount rate, the costs will
be reduced because they are uncertain in size. It is a crude way of allowing for risk because it confuses time preference with risk aversion and is an imprecise way of individual attitudes towards risk (Abelson, 1996).

Actually, decision-makers should first determine the sources of risk and assess the possibilities to lower risk and to manage it. The costs associated to risk management can be taken into account in the NPV equation.

Often, a sensitivity analysis of NPV results is performed. Commonly used approaches for this analysis are simulation and decision tree analysis. These approaches can be used to cope with the insecurity of estimating effects and estimating future environmental variables.

Decision-makers can manage the risk through ‘risk pooling’. In a well-balanced portfolio of projects it can be expected that those with the risk of losses to be at least balanced by those with a ‘risk’ of securing higher net benefits than expected (Pearce and Nash, 1981). The requirements for this argument to hold are:

- the organisations portfolio of capital projects should not be dominated by one or more large projects such that the risk on these project dominates the general risk structure of the portfolio;
- that there should be no interdependence among projects or, if there is, it should be such that this interdependence reduces the overall risk attached to the portfolio (i.e. there is a negative relation between the projects).
The choice module and a memory in COMET

After the appropriate assessment results have been assigned to the alternatives, the choice stage determines how to proceed.

11.1 Inputs, outputs and steps within the choice module

Figure 11.1 presents the choice module and its inputs and outputs. This section describes in general the inputs for the choice module, the results it should deliver and the steps to be executed. Sections 11.2 and 11.3 will present these steps in more detail.

---

**Input**

Input for this module is formed by the CRITERIA SCORECARD produced in the AA module and the objectives stated in the OS module.

**Output**

The output of this module is a new future investment map. If the FM consists of one alternative and it satisfies all objectives and it is sufficient concrete to implement, then implementation may start and the decision
process may stop. If these conditions are not satisfied, the FIM may be input for a new decision cycle.

**Steps in the choice module**

The steps which will be taken in this module are given in Figure 11.2. First, the alternatives are compared, to allow for a ranking. Then, a selection is made by confronting the ranked alternatives with the objectives and a go-no go decision may be taken if an alternative (or alternatives) fulfil the objectives.

![Figure 11.2 Structure of the choice module](image)

**11.2 Comparison of alternatives**

In this step, a comparison is made between the alternatives and with the base case (since the value of the future options is attributed to the alternatives, options do not have to be compared with the base case). In the comparison we learn the difference between the alternatives. Yet, this is not the only comparison: the alternatives' results should also be compared with the objectives to see whether these latter ones are met. Figure 11.3 is the part of Figure 11.1 dealing with the comparison of alternatives.
Inputs
The objectives and the result of the assessment stage form input for this activity, which is the CRITERIA SCORECARD.

Outputs
The outputs of this activity should be a ranking of the alternatives on the basis of their results. This can be (Janssen, 1991):

- A complete ranking: \( A > B > C > D \)
- The best alternative: \( A > (B, C, D) \)
- A set of acceptable alternatives: \( (A, B, C) > D \)
- An incomplete ranking of alternatives: \( A > (B, C, D) \) or \( (A, B) > (C, D) \)
- A mere presentation of alternatives

Whether the results are acceptable, is determined in the next step.

Methods for this activity
In this step, a translation of the CRITERIA SCORECARD into a RANKING needs to be made. This can be done by comparing the criterion values with the target values set for them in the objective setting stage. A ranking can then be performed.

Ranking takes place in two steps: first the alternatives are ranked by every individual criterion and based on this ranking, the alternatives are ranked. The different criteria may lead to a different ranking for the alternatives. This is a problem in multi-criteria analyses. Therefore, COMET does not use a multi-criteria approach here, but leaves it to the decision-makers to discuss which alternative is better.

A problem of a different kind is the ranking of criteria at the nominal scale (for example a ranking by size or colour of a product). No rules can be given for this ranking. Again, decision-makers will have to discuss on the ranking.

Presentation of the ranking can be done by giving the cells of the CRITERIA SCORECARD a colour, leading to clear visually distinctive patterns for the alternatives, as is done in the running example (see also Janssen,
The breadth of ranges used for the ranking can be determined by the decision-makers on the basis of discussions.

Running example: RANKING at TG

The CRITERIA SCORECARD of TG transferred into a RANKING. The decision-makers at TG may come to a ranking on the basis of confronting the alternatives with the objectives. They wanted to improve administrative efficiency by 25-40% and cutting back administrative time by 50%. We altered these objectives and added additional criteria. Hence, comparison should be made with these objectives and additional criteria. The RANKING is given below. First, the criteria values are ranked and on the basis of this ranking, the alternatives are ranked. The type or ranking is given in the last column.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV + option values</td>
<td>60.000</td>
<td>137.500</td>
<td>70.000</td>
<td>A1 &gt; (BC, A2)</td>
</tr>
<tr>
<td>Customer service</td>
<td>Insufficient</td>
<td>48.4%</td>
<td>37.3%</td>
<td>A1 &gt; (BC, A2)</td>
</tr>
<tr>
<td>Employee well-being</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>(A1, A2) &gt; BC</td>
</tr>
<tr>
<td>Agility</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>A1 &gt; (BC, A2)</td>
</tr>
</tbody>
</table>

Alternative Ranking

<table>
<thead>
<tr>
<th>Alternative Ranking</th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>A1 &gt; A2 &gt; BC</th>
</tr>
</thead>
</table>

11.3 Selection

When all preceding steps of the decision process have been taken, a selection can be made. Figure 11.4 is the part of Figure 11.1 which concerns the selection.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Selection</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>New Future Investment Map</td>
</tr>
</tbody>
</table>

11.3 Selection

When all preceding steps of the decision process have been taken, a selection can be made. Figure 11.4 is the part of Figure 11.1 which concerns the selection.

Inputs for this activity

Input for this activity is the RANKING which results from the comparison activity in the choice module, as well as the objectives.
Outputs of this activity
The output of the choice module is a selection of alternatives. The selection is based on confronting the ranked alternatives with the objectives. Here, the alternatives which do not comply with the objectives may be done away with. It is even possible that alternatives which do comply, but are second best or worse than other alternatives, may disappear as well.

As a result of this step, a decision can be taken that a certain alternative should be implemented or the decision that another COMET cycle should be traversed. In both cases, this decision will be accompanied by a new, adapted FIM. In case of an implementation decision, this new FIM can be used as a starting point in a subsequent decision process. In the other case, the FIM is the basis for a new COMET cycle.

Methods
A choice should be made between implementation or starting a new decision cycle. There are two necessary, but insufficient, conditions for implementing an alternative:
1. The decision cycle ends in exactly one alternative;
2. The alternative is sufficient concrete to be implemented.
Besides these conditions, decision-makers have the freedom to use arguments to still start a new decision cycle.

FIM evolution in case of a new cycle
In the coarse COMET cycle groups, FIMs are generated from scratch. In fine cycle groups, the FIMs are reduced because of choices, and detailed in successive cycles. Consider the left-hand FIM of Figure 11.5. Suppose assessment has led to deciding for continuing with alternatives 1 and 2, in other words, the sieve is used. This reduces the FIM to the right-hand one in Figure 11.5. In general, after a choice, the FIM contains the current situation, the selected alternatives at hand and the options which can be attained via the alternatives at hand.

Figure 11.5 FIM before and after a choice is made
**FIM evolution in case of an implementation decision**

If an alternative is selected for implementation, the FIM evolves in to a new one, in which the chosen alternative becomes the new ‘current situation’, and only those options remain, that can be reached from this alternative. The right-hand FIM in Figure 11.6 is the result when a choice for alternative 2 is made from the left-hand FIM: options 4 and 6 disappear. If alternative 1 would have been chosen, all options would remain present in the FIM.

After a final choice for a certain investment is made, the FIM can be used again in new decision processes.

Decision-makers should be aware that although COMET generates alternatives and future options, there is *no obligation* to choose the future options (cf. Copeland and Keenan, 1998a). Decisions on these may be deferred. This implies that, after a go-decision is taken for the alternative, the costs and benefits of the current alternative become real, while the costs and benefits of future alternatives remain possible and uncertain.

Running example: Choice at TG

On the basis of the previous step, decision makers at TG selected alternative 1, leading to the FIM given below.

Yet, in criteria-ranking, employee-well being only scored ‘moderate’, which may trigger the decision-makers to start a new decision cycle in which particular attention is being paid to adaptation of alternative 1 to cope with this problem. In that case, the new decision cycle may generate a new FIM in which variants of alternative 1 are developed.
When all previous steps have been properly executed, the selection step may seem rather straightforward. However, we do realise that COMET is developed to support the decision process and cannot replace it. We are aware that making choices remains a difficult task.

11.4 Memory

During the entire decision process many intermediate choices are made which finally lead to a single alternative on which a go-no go decision has to be taken. At the same time, the process of decision making is performed by several persons. Different people may be active in the respective stages of the decision process. Usually there is also more than one person involved in every stage. The involvement of more than one person makes misunderstanding, miscommunication and different interpretation of the definition and the values of the criteria possible. Besides, the perception of the (relative) importance of different effects, criteria or alternatives may differ across the group of decision makers. Negotiation between decision makers (from different organisations) may be necessary and will take place during each step in the decision process.

A single, straightforward solution to prevent this problem is not available. Yet, decision makers do have possibilities to minimise the problem. Communication is key in prevention of misunderstandings. In objective setting, decision makers should have discussions to obtain a common understanding of the criteria definitions. Throughout the entire decision process, the information and knowledge gathered should be transferred from one step to another in an unambiguous way. Explicit documentation of alternatives, effects, and assessment results can guide these processes. This knowledge will be captured by a memory within COMET.

Use of a memory

A memory is useful inside and between decision cycles. It helps to keep the decision process consistent with regards to the objectives, decision criteria and chosen effects. Moreover, the outputs of different stages and cycles can be used by other groups which may join the decision process in later stages. We call this the micro-consistency of the decision process. The memory may also serve to improve the macro-consistency of the decision process. By macro-consistency we mean that the decision process is consistent in approach and use of decision criteria across different investment processes. Of course, decision criteria and their target values may change, because decisions have to be made in very dynamic settings. Yet, a memory makes it possible to keep track of the way certain decisions are made. In this sense, the memory
can present the results and approach of former decision processes. This can be used as input for decisions under consideration, thus enabling organisational learning.

The decision processes can also be made more efficient by *re-using results* of former decision processes. A concrete example is formed by the FIM. A FIM does not have to be used for just one decision process, but can serve as input for new processes as well.

The memory is not only useful during the decision process itself. After implementation of an investment, it is good practice to *evaluate* whether the investment meets the expectations which were stated in the decision process. Organisations can greatly profit from learning experiences occurring in ex-post investment evaluations (Renkema, 1996). Evaluation refers to the activities within a single investment process (of which the decision process is part of, see chapter 2). To be able to perform an evaluation, it is necessary that information on the activities which are undertaken within the decision process and the results of the decision process are available, which can be provided by a memory.

Repeating investment evaluations on a regular basis may guard against the danger of *investment entrapment* (Renkema, 1996). Investment entrapment is the phenomenon in which more and more resources are committed to the investment as a consequence of a strong emotional affinity of the decision makers with the investment. It may happen that consecutive investments are no longer subject to an analysis regarding contents.

**Contents of a memory**

What aspects of the decision process should the memory contain? Organisations should be efficient in filling the memory. Relevant material on the investments should be kept and the information should not be so overwhelming that users cannot find the important issues.

At least the results of the four COMET modules should be saved for every cycle). This implies saving

- the objectives,
- the results of the investment classification of TICS,
- the FIM,
- the criteria functions,
- the COMPLETE EFFECTS SCORECARD,
- the COLLAPSED EFFECTS SCORECARD,
- the CRITERIA SCORECARD and,
- the choices made.

Of course, these results may be augmented with, for example, names of persons or groups involved in the decision process, established agreements between stakeholders, contracts, etc.
PART III — Conclusion
Discussion and conclusions

In the first chapter of this book we presented our aim: the development of a comprehensive methodology for supporting decisions on telematics investments. A design of this comprehensive methodology is presented in the chapters 7-11, based on the requirements gathered in chapters 2-6. In this chapter we present the results of a first confrontation of the methodology with practice. This confrontation took place in the form of an expert session, in which experts both from practice and the academic world commented on the premises for COMET and the solutions which are developed in COMET.

In section 12.1 we present the results of the expert session. In section 12.2 we present the conclusions, followed by suggestions on how to proceed with the development of COMET in section 12.3.

12.1 Expert session

What follows is a summary of the discussions held during the expert meeting, emphasising the comments given by the experts.

The agenda for the expert session consisted of two major parts: a presentation in which the basis for COMET, as well as its components where introduced, and an in-depth discussion based on propositions representing parts of COMET and their assumed use in practice. At the expert session the following persons were present:
- A representative of travel organisation TG
- A representative of container terminal operator CTO
- A researcher of Tilburg University/TNO Inro
- A researcher of Maastricht University
- Three researchers of the Telematics Institute
Several other experts could not attend the session and gave their remarks and comments off-line (a consultant, a researcher of Erasmus University and a researcher of Delft University of Technology).

12.1.1 Use of the methodology

Six propositions on the use of the methodology were discussed during the meeting.

**Proposition 1**

*Telematics is intertwined with business processes. Therefore, COMET forces decision-makers to describe both telematics investments and related investments in organisational change. The result of the investments will be expressed as its value for the organisation (the business value) instead of just the value of the telematics investment.*

The experts support the starting point that telematics is intertwined with business processes. This implies that telematics investments should not be considered in isolation, but in relation with (investments in) organisational changes. Strictly speaking COMET should not be seen to support telematics investment decisions but decisions on organisational changes.

It is acknowledged that telematics investments are difficult and complex and keep attracting new issues which need to be addressed (the investment is not a telematics investment, but an organisational investment, what to do with resistance, how to support the process, etc.). It is therefore suggested to explore the possibilities of COMET to support organisational changes, broader than just through the use of telematics. A related issue is that management is more and more confronted with organisational changes, leading to the potential dangerous situation that it loses overview of the organisation and the activities taking place.

The presentation gave the impression that COMET is mainly opportunity-driven and less problem-driven. In other words: COMET scans developments which are observed in the market ('What use has the Internet for us?'). Yet, COMET should also offer support when a solution needs to be sought for observed problems within the organisation.

However, one of the methods within COMET is the SWOT analysis, which supports analysis of the organisation, next to analysis of the environment. An investment assessment without a SWOT analysis cannot be performed by COMET. In other words: first objectives need to be set by which the alternatives (telematics applications) will be assessed.

Telematics often is of an infrastructural nature, which makes assessment difficult. The HfM (using option theory concepts) tries to cope with this
problem. Yet, determining future options is seen as a difficult task, because it is impossible to foresee the kind of future developments which may take place. The alternatives at hand may be followed by an infinite number of future options. On the other hand: if it is decided to invest in a network, at least some ideas should exist on the applications which will make use of that network. Limitations in the extension of the FIM are determined by the amount of time and money available within the decision process (note that this restriction actually applies to the decision process in general and not just for the development of the FIM).

Resistance within the organisations may occur. Many issues which at first sight have no connection with the investment may suddenly play an important role. COMET tries to cope with this problem by suggesting a broad number of decision criteria which can grasp the broadness of changes. An example is employee well-being. When a decision is to be made, COMET suggests to analyse the results of the investment to this criterion prior to the decision (actually, the decision needs to be partly based on the result for this criterion).

The experts remark that organisations often underestimate the negative consequences of investments to employee well-being. Consequently, organisational changes are often more difficult to implement than expected. Currently, no method is known that takes into account the consequences of organisational changes for employee behaviour and that prescribes measures to cope with possible employee resistance. Such measures should be taken into account as expenses in the decision process. If COMET wants to take the expenses of changes into account, it should point out the measures to be taken in the decision process to overcome resistance. The expenses on these additional measures should be taken into account in the decision.

Proposition 2
Decision-makers often have difficulties in assessing telematics investments. The choice of the right decision criteria, as well as the analysis of effects which will occur are difficult. COMET offers support by:
- giving suggestions for decision criteria through a decision criteria checklist
- classifying investments along the lines of their scope (aimed at an activity, process, department, organisation, chain, network...) through TICS,
- indicating whether investments are of a relation type or of a structure type,
- giving suggestions for possible telematics investment effects on the basis of the investment classification

The experts find the division of investments into relation versus structure confusing. Besides, this division suggests a contrast, while relation investments may also lead to (investments in) structure. The experts suggest that it is more convenient to make a division in investments which take
place within processes (organisations) versus investments which take place between processes (organisations).

The investment and criteria classification lead to a scheme from which effects can be chosen. The effects are examples which decision-makers can use as a starting point. It renders a more complete picture of what should be taken into account in the decision process. The scheme cannot be static, because effects may be added and may disappear. The experts acknowledge the appropriateness of the scheme as a starting point, while mistakes being made in assessment of the investments are mainly caused by not taking all effects into account. Often, telematics investments aim at reduction of costs, disregarding other effects (like new options).

The scheme will make COMET more manageable, but the decision process not easier: the decision-maker will have to perform extra work. It can be questioned, however, whether ease of use should be seen as the ultimate goal of a supporting methodology. Yet, easiness is necessary, given the fact that the use of existing methods in practice often minimal because of their (perceived) complexity. COMET is even more advanced than current methods, making explicit attention for its ease of use necessary.

The experts question the completeness of the set of effects. For example, is the possibility to bring products to the market using telematics taken into account? Or, does COMET offer support for judging new product-market combinations which are a consequences of telematics (existing products at new markets, new products at existing markets)? Checking the scheme is therefore necessary. This can be done by comparing it with other effect schemes, but more usefully be applying it in practice and as such validating it.

**Proposition 3**

Denial of effects of future investments made possible by current investments may lead to an under-valuation of the current investments. COMET forces its users to describe the future investment possibilities of the current investment, through use of the FIM. It also attributes the effects of future investments to the current investment.

The experts confirm the usefulness of the principle, but point out that it is very difficult to indicate what future options of investments can be. If we assume that it is already difficult to find appropriate alternatives at hand, future options will be even harder to construct. It will therefore be hardly possible to quantify these future possibilities. It will usually come down to staring into a crystal ball. On the other hand, when a decision on the investment for a network will be taken, decision-makers should at least have an idea of the applications which will make use of the network.
When effects of future investments are taken into account, they should be both benefits and costs.

The experts seriously doubt whether the FIM can be applied in practice, while it will cost very much effort to construct it. A lot of aspects mentioned in the FIM will in practice be unclear and decision-makers most likely will not have the desire to perform the exercise of building the FIM. It is suggested that the focus should be put upon whether or not the current investment will limit or expand future agility of the organisation. The experts expect that this delivers enough insight into the future consequences of the investment. A disadvantage of this approach is that organisations have a tendency to wait for the technology to be full grown, as has happened in the building industry.

The approach should not be to express all effects in money, while it is expected that the option-concept will in practice be very difficult to express in money.

**Proposition 4**

In practice it appears difficult to express the effects of telematics investments in financial terms. COMET therefore offers a combination of financial and non-financial (quantitative and qualitative) criteria. COMET offers a more complete insight into business aspects, (inter)organisational aspects and technical aspects.

The experts support this approach. The methodology uses non-weighed multi-criteria (the effects which serve as input for the criteria may be weighed). In contrast with Information Economics, all criteria are not brought together by using a single denominator. Decision-makers can choose on the basis of the CRITERIA SCORECARD. This may actually lead to an implicit weighing by the decision-makers, but this is not done in advance. A decision has to be taken on the current situation, which should determine the relative importance of the criteria.

The experts also support the idea within COMET not to ‘deduct’ risks from the result (as is done in the Information Economics approach). Decision-makers should seek measures to limit or manage risks. Costs of these measures should be taken into account in the costs-benefits calculation. It is suggested to use the term ‘uncertainty’ instead of risk. Some issues are not known, but this does not imply that they will be a risk. A risk can be reduced by taking appropriate measures.

**Proposition 5**

COMET uses Net Present Value (NPV) as the financial criterion. The user has the freedom to decide whether or not to express effects financially. If effects are made financial they must be used as input for the NPV. COMET offers support in financially expressing the effects.
Whether as much effects as possible should be made financial depends on the preferences of the decision-makers. It should be kept in mind that when translating effects into financial terms, certain assumptions are made which influence the final outcome. This implies that a NPV is less solid than it appears. A final choice will be determined by negotiation, where politics most certainly will play a role.

In practice often a combination is made of a cost-benefit analysis and 'softer' criteria, where the latter criteria are often valued by personal, informal judgement.

The experts acknowledge the appropriateness of using the NPV over the payback period because the former criterion gives a better indication of the financial consequences of the decision. Yet, it is suggested to also offer the payback period within COMET, since the bulk of the organisations use this method and decision-makers find it easier to use than the NPV. For practice, the payback period cannot be disregarded (and note that it can be easily extracted from the inputs for the NPV). The 'Mosselman-criterion' presents both NPV and payback period to its user.

**Proposition 6**

*In order to come to better insight into the consequences of inter-organisational telematics investments, it is necessary to not only analyse the investment at the organisational level, but also at the chain or network level. COMET forces its users to take all effects of the investment into account in the description of the investment. It offers support by using a process view, allowing to disregard organisational borders.*

The experts emphasise that for inter-organisational investments the scope should be at chain-level by definition. This approach is already being applied in practice, although due to other causes. It is stated that a small actor in a chain will most likely focus upon itself. A large organisation can apply its will to other parties within the chain and there may be tight dependency relations between organisations.

Organisations which do not have a view across the organisational boundaries are often afraid to give away strategic information to their competitors. However, the experts find this a weak starting point for cooperation. Decision-makers should be able to see win-win situations. Yet, COMET can still offer the process-approach to these organisations. By applying the process view, it can be shown that the approach is not really different at a chain level than applied within a single organisation.

### 12.1.2 Structure of COMET

Four propositions on the structure of COMET were discussed during the meeting.
Proposition 7
A memory is a useful means to transfer the results of the various steps in the decision process (objectives, decision criteria, alternatives and assessment results) between the different participants.

Proposition 8
A memory leads to improvement of the decision-making process in the long run by preserving learning effects of past decision processes and by transferring the results to new decision processes.

The experts find a memory not only useful, but a necessity within the methodology. While results of investments cannot be derived from current accounting practices, it is necessary to maintain the objectives which needed to be achieved by the investments to see whether the results actually comply to those intended. In contrast, Information Economics indicates what values the criteria get, but whether these values are actually achieved cannot be traced back.

It is also necessary to describe the way the effects will be measured (defined and made measurable). This can be used a steering mechanism during implementation of the investment and afterwards the investment can be evaluated on its contribution to the objectives.

Another reason to use a memory is to guarantee the continuity of the use of the methodology itself. It is expected that users who can afterwards trace back the steps taken in the decision process and see the actual results, will be more inclined to use the methodology again. In other words, for learning effects and evaluation purposes the memory is necessary. The form in which the memory will be offered to the decision-makers will be important for its actual use.

Proposition 9
Decision-making in the area of telematics investments can be considered to be a cyclic process. Each cycle contains the steps objective setting, alternatives generation, alternatives evaluation and a choice. In this way objectives, alternatives and assessment results are determined and iteratively adjusted and refined. COMET follows the cyclic process and consists of modules which offer support for each stage in the cycles. Because stages in different cycles differ from each other, the modules contain several forms of support.

The model resembles Simon's model of decision-making (1957). It is stated that decision-making in practice never takes on this form. The path in practice is usually the other way round: a choice is being made and when doubts on this choice are expressed, an appropriate objective is sought to rationalize the choice. However, structuring of decision processes is
important, especially to gain commitment of the stakeholders. We should note that the stages in the decision process do not follow a top-down approach. It can be started by alternatives generation: market developments are being observed and the question is raised whether the organisation should do something with these developments. Besides, all sorts of adaptations of objectives, alternatives, criteria and effects can take place.

Usually, several decision processes take place at the same time within the organisation. These decision processes will influence each other and interact with each other. Perhaps it is possible to keep track of the number of decision processes within the methodology.

**Proposition 10**

Combining of (parts of) existing useful methods within a comprehensive methodology lowers the threshold to use the entire methodology, because users and decision-makers know the existing methods.

This proposition holds if the word ‘because’ is being replaced by ‘if’. Moreover, methods should not only be known, they should also have proven themselves.

The methodology should be a framework from which decision-makers can pick appropriate methods, but also can add methods. The final form of COMET will for a large part be responsible for the actual adoption and use of it. Aspects which should be taken into account are:

- COMET must be easy to use and the results must be easy to understand
- COMET should have an appealing ‘interface’ and most likely has to be presented to its users in the form of a tool.

COMET must be friendly for its user. A way to achieve this may be to offer it in different forms, ranging from a simple ‘starter’s package’, through intermediate forms into a full-fledge methodology containing all methods suggested.

**12.1.3 Other issues raised**

Within the discussions held during the expert meeting some other relevant issues were raised as well.

**COMET’s modularity**

A question is raised whether the modularity of COMET implies that the modules can be applied in isolation. This is one of the starting points of the development of the methodology and should in principle be possible. Yet, during development, tight relations are suggested between the TICS-scheme,
the HIM and the assessment which follows. Practical application of COMET should give insight into the possibility of applying the modules in isolation.

The decision-makers
The experts strongly believe that decision-makers take too little time to think investment decisions over. It is even suggested that decision-makers in practice tend to postpone large investments and focus on small (cosmetic) changes, making necessary re-organisations more difficult and painful. COMET may alter this line of thinking of managers. Telematics should not be considered to be a cost entry which should be reduced as much as possible. This approach disregards effects and puts entire organisational changes in the hands of IT programmers. The appropriate management level should be involved in the decision process. Yet, managers appear to have a natural resistance against methods. It therefore needs to be proven that COMET works.

12.2 Conclusions

In the previous chapters we presented requirements for and a design of a comprehensive methodology for supporting telematics investment decisions. Based on these results and the discussions in the expert session the following conclusions on COMET can be drawn.

COMET's scope
One of the requirements for COMET is that it should not consider telematics investments in isolation, but in relation with (investments in) organisational changes (the investment is not a telematics investment, but an organisational investment, what to do with resistance, how to support the process, etc.). As such, COMET should not be seen to support telematics investment decisions but decisions on organisational changes. When taking this stance, COMET may be useful for supporting other investment decisions as well.

COMET's cyclic nature
COMET follows the line of the decision process model as presented in chapter 2. The experts recognise and acknowledge this structure, but at the same time emphasise that decision-making in practice never takes on this form. However, structuring of decision processes is important, especially to gain commitment of the stakeholders.
COMET's appearance
Currently, a first design of COMET is presented in chapters 7-11. As such, it exists on paper. In order to test it in practice, it should be made operational, most likely in the form of a computerised tool. Next to that, the methodology must be user-friendly, suggesting a structure which is easy to comprehend and with an appealing interface.

Use of the FIM
The FIM (using option theory concepts) tries to improve assessment of alternatives which themselves hardly render benefits. Yet, the experts see the determination of future options as a difficult task, because it is impossible to foresee the kind of future developments which may take place. The alternatives at hand may be followed by an infinite number of future options.

On the other hand: if it is decided to invest in a network, at least some ideas should exist on the applications which will make use of that network.

Use of TICS
By offering TICS in alternatives generation, COMET offers support in finding telematics effects. Yet, the experts find the division of investments into relation versus structure confusing and it suggests a contrast. They suggest a more traditional division in investments which take place within processes (organisations) versus investments which take place between processes (organisations).

Use of CEF
By offering a categorised effects framework, COMET offers support in finding telematics effects. This scheme is useful in preventing mistakes made in assessment because not all effects are taken into account. Yet, the framework cannot be static and it can be questioned whether a complete set of effects can be rendered. This asks for further research, both on which effects to take into account and how these effects can be taken into account. This can be done applying CEF in practice and as such validating it.

Financial valuation of criteria
COMET suggests NPV as financial criterion, next to several other criteria. The methodology leaves it to its users to decide whether they make effect values financial. When users decide to make the values financial, the effects serve as input for NPV.

The experts emphasise that it should be kept in mind that when translating effects into financial terms, certain assumptions are made which influence the final outcome. This implies that a NPV is less solid than it appears. A final choice will be determined by negotiation, where politics
most certainly will play a role. This is currently not recognised within COMET.

**Use of a memory**

In chapter 11 we suggest to develop a memory within COMET to maintain results of stages within and between decision processes. The experts see this development as an absolute necessity for successful use of COMET. This clearly asks for further research.

12.3 Further work – adaptations to COMET

This book presents a first design of COMET. By emphasising the fact that it is a first design, it is clear that more work can and needs to be done. The expert session already offered a number of entries which can be further explored. In this section, we suggest three areas to which the work can be expanded: the theoretical foundations, COMET’s use in practice and the way decision-makers can jointly make use of COMET.

12.3.1 COMET’s foundations

The first design of COMET is mainly based on the CBA-concepts from welfare economics. Yet, they are expanded and added with concepts from many other theoretical areas, most notably from organisation theory, theory on strategic management and option theory. Currently no problems are seen in the combinations of the concepts, but more in-depth research can be performed on the alignment of the different concepts used. Next to that, COMET is suggested to be a framework out of which decision-makers can use methods, but also can add methods they prefer to use and which are currently not in the framework. Research can focus upon the possibilities on how to extent the methodology and which boundaries/limitations should be considered.

A specific part of COMET which asks for elaboration is the structure of the options within the HIM. Currently, the HIM can only treat options as being independent. Research can be performed to make the HIM more intelligent to deal with the differences between dependent and independent options.

12.3.2 COMET’s use in practice

A first confrontation of the methodology with practice took place in a controlled situation. To find out the actual use of COMET, it has to be applied in practice, most likely by means of case research. Yet, at this moment, the methodology exists on paper. To actually apply it in practice it
must be refined and made operational, probably via the construction of a
tool on the basis of the first design, as suggested in the expert meeting. By
applying it in practice the entire methodology can be tested: its structure,
its components, the criteria and effects suggested, its ease of use, etc.
A number of issues should be emphasised when COMET is tested in practice:
- In chapter 6 not all cases rendered clear input for the propositions.
  ‘Unclear’ implied that the analysis of a case did render neither clear
  support nor clear rejection of a proposition. In chapter 6 we suggested
  that the unclear results should be taken into account as critical notes on
  the basis for the methodology and be tested during practical application
  of COMET.
- Next to this, chapter 6 introduced a large number of requirements to
  the methodology. Practical tests should also focus upon the validity of
  these requirements to COMET.
- Likewise, special attention should be given to the comments made
during the expert meeting. This hold in particular for those on the
completeness of the set of effects and the construction of criteria
functions, use of the HIM with its associated option concepts and the way
a memory can be constructed.
After application of COMET in practice within different situations, the first
design may be adapted, extended and re-adjusted, leading to a new, more
refined version of the methodology.

One of the suggestions made during the expert meeting is the development
of a range of COMET versions, from a ‘starter’s package’ to an ‘expert
version’. This may lead to quicker acceptation and use of the methodology.
Research has to be performed on how to offer a range of COMET products,
followed by research on use and usefulness of various COMET forms.

12.3.3 Inter-organisational co-operation and negotiation

One of the generic requirements to COMET presented in chapter 1 is the
need for an inter-organisational approach. Three issues were raised: inter-
organisational co-operation, inter-organisational description of the
investment and inter-organisational assessment of the investment. By using
a process view, TICS and the HIM, COMET allows for the inter-organisational
description and assessment. (Inter-organisational) co-operation is currently
under-exposed with the methodology. Co-operation is obvious for
situations in which decisions on inter-organisational telematics investments
should be taken. But also in intra-organisational situations, different parties
can be present, for example when different departments or business units
are involved. Though the decision process will contain various steps which
ask for co-operation, each stakeholder will have specific considerations that
he wants to take into account. Besides, it may be efficient to divide the work among the parties involved.

We therefore suggest to explore the possibilities to model decision-making at a high level as a 'multi-zipper' process as in Figure 12.1. Some steps are carried out in co-operation, other in isolation. All modules within COMET can be used in both situations. Of course, more complicated situations (with e.g. more than two groups of stakeholders) are possible.

By making explicit that certain steps are taken isolation and others in co-operation, the multi-zipper can be used by the decision-makers to structure, plan and trace their activities within the decision process.

![Multi-zipper model for decision-making](image)

The multi-zipper models various moments at which the decision process is split up and rejoined. Splits and joins are critical steps in the decision-making process, which makes clear agreements between the decision-makers necessary. The split and join are further explained below.

**The split**

The splits in the zipper indicate that decision-makers separate and perform a part of the decision-making without the other stakeholders. This can in principle be in any stage of the decision cycles: decision-makers may want to set their own criteria, may want to find their own alternatives, and may perform their own assessment. Especially assessment will be a clear candidate for splitting the decision process. Another reason for splitting the process is that of efficiency: some parts of the process may be (concurrently) worked on by small groups, which can shorten the process and make it less costly. Of course, also the whole coarse cycle-group may be separately performed. The fine cycle groups can only partly be executed without the partners: a final choice should be made in mutual agreement.

When decision-makers decide to split up the process, clear agreements should be made on what is going to be done in the consecutive steps and what results in which form should be aimed for. Furthermore, to overcome diverging of the decision process and misunderstanding of results when the processes join, decision-makers should not have conflicting objectives and should have the same notion of the terms used in the decision process.
The join
Naturally, the joins, which are the points where the multi-zipper closes, are most critical. It should be made sure that isolated results are integrated, in order to proceed as one. This may require substantial negotiation or even compensation. The memory within COMET, containing all relevant information on the preceding activities within the process, may be of use here. When the isolated activities are brought together, comparison of their results is necessary, while differences in approach of the activities and interpretation of results may occur. The decision-making process should end in a cycle of which the choice stage is co-operatively executed.

Negotiation
The multi-zipper may be used to support negotiation. This is currently an underdeveloped aspect COMET. If a ranking of the alternatives is not possible or does not lead to consensus among the decision-makers, a negotiation activity may be started. In this step, negotiation on which alternative to choose, negotiation on division of costs and benefits among the stakeholders, negotiation on operational aspects, etc., may take place.

Multi-zipper forms
The multi-zipper can have different forms, depending on the relationship between the stakeholders. When stakeholders have a tight relationship, the multi-zipper will be strongly coupled, containing hardly any splits. When stakeholders have a loose or irregular relationship, the multi-zipper will be more loosely coupled, containing more splits. Another form of the multi-zipper can be found when a single organisation starts a decision process, in which in later stages other organisations join.
Interview scheme

This scheme is a guideline in discussing a planned or implemented inter-organisational telematics investment. The goal of this discussion is to analyse why the investment is or will be implemented, what criteria are used in the assessment, whether the investment is in alignment with the organisation’s objectives, where problems occurred and whether there have been any unexpected (positive or negative) situations. Next to that, we like to discuss the way co-operation with partners took place (if applicable).

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<tr>
<th>Interviewee</th>
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<td>Organisation</td>
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The following questions serve as checklist to structure the interview.

**General characteristics of the organisation**

1. What are the activities which the organisation performs/Which are the most important ones?
2. What is the size of the organisation (in terms of employees, locations, turnover and production units (for example, the number of trucks))?
3. What organisational structure is in place?
4. What are the most important customers; how does co-operation take place?
5. What are the most important suppliers? How does co-operation take place?
6. What are the most important competitors?
7. What are the most important environmental developments (legislation, market, etc.)?
8. How many years does the organisation already make use of IT-equipment, which equipment is this?
9. What experience do you have with IT? Can you explain?
10. What have you learned if you IT experience with respect to its use (where are the problems)? Do you store your experience in a certain way?
11. Did the use of IT and telematics lead to new activities (for instance, new services)?
12. How often do you on average change software and hardware? What kind of changes are these (changes to the systems, OS, networks, applications, functionality)? What is usually the occasion to make the changes?
13. Is the decision process on IT and telematics investments different from other decision processes in the organisation. If so, why is their a difference and it what respect does the process differ?
14. How easy or difficult is it to estimate the use of IT and telematics?

We see the decision process as a cyclic process. The steps to be performed will be taken several times until a final decision is made. Within each cycle we recognise the stages objective setting, generation of alternatives, alternatives assessment and choice. Does the decision process in your organisation resemble this cyclic nature, or is it clearly different? In what respect is the decision process different?

The following questions are related to the decision process and are structured along the line of the stages we recognise.

**Objective setting**

1. Who are normally involved in this stage (function)?
2. What is usually the occasion to consider certain investments?
   - partners in the chain
   - competitors
   - own ideas
   - branche organisations
   - shippers
   - experts from outside
   - IT-suppliers
   - success by others
   - different, notably...
3. What is the relation between the organisation's strategy and investments in IT and telematics?
4. Does the organisation have a IT and telematics strategy?
5. Is this strategic vision input for adjustments of the corporate strategy?
6. Does the organisation have an explicit policy on using IT and telematics for the business processes? Is this policy laid down in a certain way?
7. What importance do you attach to IT and telematics for the business processes? Is there a difference between strategic and operational decisions (for instance in the way they are structured)?
8. What are in general the expectations on the use of IT and telematics?
9. Who in your organisation takes the initiatives in the field of IT and telematics; would you characterise this as a top-down approach or a bottom-up approach?

10. Did you set objectives in co-operation with your partners; how did this objective setting take place? Bi-lateral or multi-lateral?

11. What was/is the objective of the investment?

12. What was/is the size of the investment (absolute or relative to other investments)?

13. Which (fixed) criteria are used to assess solutions? How is the life-cycle determined?

14. Do you set restrictions (minimum or maximum levels) to your criteria? If so, how are these determined?

15. What need for support does the organisation has in determining the objectives and how should this support look like (for instance, a method, an expert, a computer, etc.)?

Alternatives generation

1. Who are normally involved in this stage (function)?

2. Can you indicate how your organisation acquires knowledge on new IT and telematics applications? Does the management has experience with automation (satisficing versus optimising)?

3. How does the organisation determine whether new applications, new technology and associated possibilities are useful for the organisation?

4. In what way are new telematics applications noted or found by the organisation?

5. Who in your organisation take care of gathering and dispersing knowledge on IT and telematics?

6. Does the organisation itself search for IT and telematics solutions or is this activity sourced out?

7. Are solutions sought in co-operation with partners? How does this take place?

8. What need for support in searching for solutions does the organisation has and how should this support look like (for example, a method, an expert, a computer, etc.)?

Alternatives assessment

1. Who are normally involved in this stage (function)?

2. In what way are alternatives assessed; is a fixed procedure used?

3. Based on what criteria do you choose for a certain alternative (Secondary effects and future opportunities)?
   - Strategic criteria
   - Competitive advantage
- Risk
- Not executing the investment (opportunity cost)
- Financial
- Technical
- Project
- Management
- (hard and software) supplier
- Quantifiable criteria
  - Net present value
  - Payback period
  - Effect to productivity
- Qualitative criteria
  - Improved customer service
  - Improved product quality
  - Improved job satisfaction
  - Improved flexibility
  - Improved business relations
  - Improved corporate image
- Different, notably:

4. How do you estimate the effects and where do you get the relevant information?
- External (business processes at a chain level)
  - Aspect of the market
  - Aspects of the (telematics) supplier
  - External financial factors
  - Legal or juridical factors
- Internal
  - Internal financial factors
  - Technical aspects of the investment
  - Relations with stakeholders
  - Employee-related factors
- Different, notably:

5. How are the criteria appraised (what is the input to calculate them)?
6. Is/are certain criteria more important than others? How do you determined that?
7. What was the most important reason to implement previous IT projects (satisficing vs. optimising)?
8. How are costs and benefits estimated and weighed?
9. Do you perform a risk analysis? Do you take action to reduce risk, and if so, how do you do that?
10. Do you co-operate in this step with partners? How does this take place?
11. What need for support does the organisation have in assessing alternatives and how does this support should look like (for example, a method, an expert, a computer, etc.)?

**Choice**

1. Who are normally involved in this stage (function)?
2. Who, internally, has influence on the final choice (function)?
3. Who, externally, has influence on the final choice (function)?
4. Which activities do take place in this stage?
5. Does the organisation co-operate with partners in this stage, or perhaps negotiate on the results. How does this take place?
6. What need for support does the organisation have in this stage of the decision process and how should this support look like (for instance, a method, an expert, a computer, etc.)?

**Evaluation of the decision**

These questions only need to be answered when discussing a decision which already has been taken.

1. To what extent was the decision successful?
2. Were there any unexpected positive effects; which ones?
3. Were there any unexpected negative effects; which ones?
4. Was the way in which the decision process took place satisfactory? If not, what would you change?
5. Were there any delays, unforeseen circumstances or disruptions during the decision process? In what stage of the process did this take place and what was the cause?
6. Did information become available during implementation of the investment or afterwards, which would have had influence on the decision?
7. Did information become available which you would like to have had earlier; what information?
8. Took the decision process a gradual pace in which it was unclear beforehand which directions would be considered?
9. What was your stance vis-à-vis the investment before the implementation?
10. What was your stance vis-à-vis the investment after the implementation?
11. Did (temporary) project teams work on the investment; what was their purpose?
12. Did differences in opinion occur during (parts of) the decision process? Think of the objectives, the assessment procedure, personal objectives, pace of the procedure, clash of characters, responsibilities, etc...
13. If you look back at the decision, where would you like to have had more support? What form should this support have?
Case descriptions

The case of transport organisation TA

This case describes the decision process on the introduction of EDI within a transport organisation, which we named “TA”.

TA and its environment

Transport organisation TA is a family-owned and operated company, which exists 27 years. The main activity is transport, in which air-freight trucking accounts for approximately 70%. The core activities are international transport, national transport (distribution) and warehousing. TA’s head office is located in the Netherlands, while several local offices are present at airports throughout Europe. TA operates circa 300 trucks and employs about 500 people. The main customers of TA are airlines for international transport and air-freight forwarding companies for national distribution. Next to them, TA has some customers which demand specialised transport, while they ship high-value goods, such as electronics and medical equipment. TA plans to expand Value Added Logistics activities. TA cooperates with a number of other transport organisations. With some large transport organisations freight is frequently exchanged. These exchanges are based on verbal agreements (the shipment department contacts the other organisation and when the latter organisation can handle the freight, a price is determined). Some (small) transport organisations permanently drive for TA. TA only has a small number of real competitors, because air-freight trucking is a rather specialised discipline (all trucks are adapted to air-freight transport).

TA has agreements with its principals (the airlines), but does not see these agreements as a contract, in the sense that the amount of freight constantly changes. The agreement consists of transporting freight from
location A to location B, for which a certain tariff is applied, depending on the gross weight or the number of air freight pallet positions. Airlines are free to determine which transport organisation they choose. With some companies contracts do exist, for example, to handle all road transport within Europe. TA does not strive for fixed contracts or certain forms of co-operation, although TA feels that it is good to have a kind of contract for Europe with large principals, because it provides TA with a solid basis. TA's aim is to utilise the trucks as good as possible. This implies that TA must be able to acquire freight at as many places as possible.

TA uses a central administrative system, consisting of order-entry, planning, fleet management, human resource management, hour administration, financial management and invoicing. The trucks have on-board computers for registration of hour worked and communication. The international trucks also make use of global positioning. TA's head office has a link with all branch offices.

For communication with customers, TA uses EDI which is applied at five different levels. EDI is used to send and receive orders and to exchange status information on freight. TA is currently working at in-house integration of the various systems available and at making the in-house databases more transparent. Its aim is to be able to better analyse information and to obtain steering information. Integration with partners is not aimed for. Separation along the lines of the organisational borders can be clearly defined and makes a better structuring of the information possible. Besides, this separation is based on security issues.

TA developed a software application which makes it very easy for the customers to send electronic messages. Because of this simplicity and the low investments required by the customers, they can easily join in, but also easily back out. The application simplifies communication between TA and its customers. It is frequently asked for by customers, because they do not only want to place orders, but also want to receive status information.

TA made a plan in which the requirements to the systems were laid down. The actual building of the application was done by a software house. No standard package was available for the activities which TA uses the application for. TA carried the burden of the investment itself, making the threshold for participation by the customer as low as possible. Airlines use their own systems and exchange messages already for a long time, using a wholly different exchange format. TA is not in the position to change those systems; if it wants to communicate with airlines, it has to find ways to align with their ways of communicating. The application of TA makes it possible for airlines to send the same messages to TA as they are used to send to others, whereas TA sends the same messages (status information) back to the airlines as which they expect to receive from other parties.
The decision process

The decision process can start in several ways and is not linear: somebody in the organisation proposes ideas or the organisation is confronted with new technology which might be interesting. In the next step, TA determines whether the new technology can be applied and whether it is technically feasible. TA roughly determines the possible advantages and disadvantages and whether the project can be realised for a reasonable price.

The overall objective for TA is to make profit and to achieve growth. TA has a corporate strategy in which IT plays an important role. The goals and strategy are (continuously) dynamically determined. The added value of IT is confronted with the goals stated in the strategy. IT and telematics are very important for TA and have top priority. TA continuously strives for improvement of processes by means of IT, in order to augment efficiency and, when possible, effectiveness. Savings of process costs are important because the margin of TA is under continuous pressure. Another reason to invest in IT is to establish an innovative image, which is seen as a strategic issue.

EDI-trajectory

The trajectory towards the current communication system was triggered by requests by customers of information on status and location information of cargo. The actual start of the EDI project was triggered by a demonstration project on electronic message exchange by a local branch organisation. TA joined the project, together with a major customer. Both parties did not have prior experience. The project was supervised by a consultancy agency, which was hired by the branch organisation. The input for TA in the project concerned time and adaptation of systems. First, the organisations needed to learn each others systems, international issues and way of working. Next, exchange messages were defined. TA decided to put in more effort in the project and developed a whole scenario for message exchange, in which orders are received and planning information is sent back. Next, status information on picking up and delivery of goods are sent to the customer, with information on possible discrepancies between planning and actual status. Finally, a conformation is sent. The entire scenario was made in a single effort for both organisations, making it possible for both of them to send and receive messages. Despite the amount of work, this approach turned out positive. The message set was implemented and served as a basis for further developments. Currently, TA offers five ways for the customers to deliver information and request status information. For the project a rough estimation of the costs was made, which was necessary because the project was partly subsidised by the Dutch Ministry of Transport. The subsidy obliged TA to make a project description, perform a feasibility
study, realise/implement the project and demonstrate the results to the sector. The feasibility study consisted of an inquiry of the customers of TA. TA inquired both large and small accounts, as well as customers from the Netherlands and Europe. The inquiry consisted of questions related to the systems customers currently operate and the demands they have. On the basis of the inquiry, requirements for the EDI-system were derived. Before the start of the project, an estimate was made of the costs (another requirement to obtain a subsidy). The subsidy was not the main reason to execute the project, as it would not cover all costs. The estimation was made on the basis of expected costs and expected time spent. TA did not perform an in-depth analysis, because this would take too much effort. During the course of implementation, several checks were built in to compare actual expenses with budgeted expenses. The estimation was based on experience with another project. From that project TA had learned that estimated time effort was too low and that external parties hired were more expensive than estimated.

During the decision process, TA assessed hardware and software suppliers on their ability to deliver the components necessary in the project. TA assessed the suppliers on their capability and flexibility in making the requested components, their bidding price, organisational size and continuity. TA does not necessarily works with the same fixed group of suppliers.

A customer can a choice for one of the five levels of electronic communication on the basis of the systems which they have themselves. Alignment of TA’s and the customers’ systems is never 100%, customers usually have specific requests. Mostly, TA is able to deal with those requests, but does not want to offer all kinds of dedicated solutions. Offering a complete set of five levels of communication possibilities has a positive effect on the image of the organisation and makes implementation easy once the customer has chosen a certain EDI-level.

**IT importance**

IT is seen as a strategic issue. Competitive advantage is an important decision criterion and was taken into account in the first stages of the decision process, although not explicitly. When the IT department proposes a project to TA’s management for approval, it is already clear that the project is technically feasible. As such, TA does not explicitly takes risk into account. Another reason for that is that TA makes use of existing technology, which only requires small adaptations. It is hardly possible to estimate the financial contribution of electronic communication. The fact that this new technology can attract new customers, could not be taken into account. Effects to productivity also played a minor role. TA was aware of efficiency benefits: when the customer executes the order entry, TA does
not have to do it, thus saving money. Yet, the strategic importance of the project prevailed all other criteria. TA did not determine a payback period, partly because they are hard to determine for this kind of investments. Payback periods do get determined for investments in direct value-adding activities, for example for a warehouse.

Replacement and expansion of IT takes place on the basis of proposals of the IT-manager. TA feels that many IT investments are difficult to justify. Justification is often sought in the expectation that extra cargo and customers can be acquired through improvement of organisational image, but does not by all means strive to justify IT in financial terms.

**Results and further developments**

The project did not encounter unexpected negative situations. Some of the estimated costs turned out slightly higher, but that was minimal and mainly caused by addition of extra functionality. The project results are demonstrated at several European locations for local customers and prospects. This led to several publications, resulting in new contacts with companies with which currently a relationship exists. Although these effects were intended, they could hardly be projected in advance. Some delays in implementation occurred (about three months) but this was mainly caused by the fact that TA choose to offer five instead of three levels of electronic communication. With regards to timeliness of information, TA concludes that several remarks and requests by customers would have been useful when given during the decision process, instead of afterwards. The feasibility study could have been performed in a more in-depth manner.

TA plans to improve and enlarge the communication possibilities with customers, based on requests by the customers. The message set used is standardised as far as possible, partly because some information is always necessary. Extension of the message set is currently not foreseen and when it happens, TA opts for standard solutions. TA strives for communication by means of EDI with as many as customers possible, but does not expect 100% coverage. Especially smaller organisations are hard to convince of the use of EDI. TA does not see the existence of two communication systems (EDI and ‘traditional’) as a problem.

When available, TA would use a method to support the assessment of alternatives, but wonders whether such a method can be developed. It should be applicable to several situations. TA would use a memory in which can be put down for what reasons a certain investment is chosen and what its results are. It would be used in the form of a checklist. It can be particular useful to compare different projects which are executed at different moments in time.
The case of container terminal operator CTO

This case describes the decision process on the introduction and use of EDI within a container terminal handler, which we named “CTO”.

CTO and its environment

CTO is a terminal operator which is active since 1969. The main activity is transhipment: loading and unloading of ships, and delivery through the modalities road, rail and inland navigation. CTO operates five terminals, each of which has its own customers and way of handling. CTO has a board of directors which give direction to two divisions. The annual turnover is £650 million and CTO employs about 2100 people and approximately 300 flex-workers. CTO spends approximately 8% of turnover on total IT. Every day 2000-2500 trucks arrive at the gates of CTO. CTO handles 2.5 million containers at the sea-side. At the land-side 1.9 million containers are handled, leaving 0.6 million containers for sea-sea transhipment. Approximately 70% of total container handling within the harbour is performed by CTO. Direct customers of CTO are ship owning companies, indirect customers are feeder operators, rail operators, inland navigation operators and road transport. Within the harbour, CTO meets some competition, but the main competition is between harbours in the North of Western Europe. Investments in physical infrastructure, especially in the network at the land-side through all modalities, are very important to CTO. Yet, CTO perceives the developments concerning infrastructure as taking a very long time. Legislation is of no direct influence on CTO, at most derivatives of it.

The decision process

Since the 1970s, CTO has taken several major steps in IT. Telematics is used in many external relations, but also for the support of terminal processes. For example, the communication at and with the robotised terminals is executed through telematics. In 1988-89, telematics is embedded within the organisation in a new fashion. By then, CTO recognised the major (strategic) importance for the organisation, requiring enough resources. This strategic reorientation of telematics was initiated by top-management. CTO has experienced the difficulty of making just one department responsible for external telematics, while telematics relates to commerce, marketing, IT and the core processes. Currently, CTO starts developments in the user departments (i.e. the operations). IT projects are supported by production support, a department which forms a liaison between IS and operations. EDI is part of tasks of several people in several
departments; the IS-department employs several EDI specialists. CTO processes over 30,000 EDI-transactions per day.

In 1989, CTO developed a structured plan for EDI. This plan led to one vision among the different decision-makers. A plan like that forces organisations to consider various aspects of EDI: which priorities need to be determined, what volume of transactions is under consideration, what is our external environment, what are the large players, what are the small players, do we start at the sea-side or at the land-side, do we develop the components ourselves or not, etc. The development of the plan took several months and acquired reasonable consensus. A problem was that the group working on the plan was small relatively to the rest of the organisation. Looking back at that period leads to the conclusion that no solid base for EDI existed within the operational departments (mainly because they had never been confronted with EDI developments). The plan was developed at management level and consisted of several components emphasising both external and internal aspects. The internal part consisted of an information sessions part and an IT part. Many internal information sessions were held to explain management expectations with regard to EDI. Such sessions are still in use, for example to gain support for new developments. Currently the EDI plan is no longer in use. At the sea-side, CTO has developed a complete scenario, at the land-side the success depends on two projects which are currently undertaken by CTO and many other organisations within the harbour community.

Within CTO many discussions take place about developments in the environment and their repercussions on the organisation. CTO regards itself as a small part of a very large logistic chain and constantly searches for possibilities to tie customers to itself. CTO is closely involved in activities concerning the entire harbour and uses a pro-active approach, making it possible to steer its partners. Besides that, CTO is very active within the international standardisation circuit, while recognising the importance of standards for electronic communication. The telematics initiatives no longer stem from a plan, but appear as more regular projects. Necessary adaptation of systems or new developments are now proposed as new projects. Telematics is no longer seen as separate issue, without linkage to the organisation. Initiatives mainly come from the own organisation, but partners and branch organisations play a role as well. Actions by competitors usually form no occasion for action, although CTO co-operates with them for standardisation. EDI and telematics are clearly rooted within the corporate strategy and are supported by the entire organisation. CTO has a telematics strategy, but telematics investments cannot be seen separately from the regular IT budgets. Besides, CTO tries to link telematics investments to IT projects where applicable, in order to create
integration of applications. In every IT development trajectory, account is taken of the possibility to integrate EDI. It used to be difficult to perform separate cost benefit analyses for EDI, but this is nowadays less relevant. Adaptation of EDI now forms part of replacement and expansion investments, which have to be done anyway.

CTO has split up the EDI infrastructure: it contains an EDI server, which deals with EDIFact messages and forms the gateway to the external world, so-called EDI-handlers to process customer-specific EDI messages, and the end-applications which steer the operational process. By doing so, changes in EDI no longer influence the end-applications and customer specific demands cannot not interfere with the operations. However, EDI messages are tightly linked to the operational process. CTO choose to work with standard networks and standard communication protocols in order to limit the number of technical possibilities and to obtain a certain level of secure information exchange.

CTO is not in a position to realise all ideas it generates. It therefore tries to convince parties within the harbour that they can be benefit from joint activities. Next to that, CTO tries to involve its partners in its EDI-projects, although the establishment of co-operation is not always easy. At the sea-side the division between EDI messages and traditional messages is 70-30 and CTO strives to attain 100% EDI exchange. By making a clear difference in prices, CTO expects to reach that goal. At the moment, CTO has several message scenarios ready and when a customer shows interest in communicating through EDI, agreements are made on which scenario to use. Then, a test project is set up for both the customer and CTO. In the test project the organisations determine which connections will be used and how communication will take place. The development of a complete set of scenarios for the sea-side took about five years. At the land-side, CTO tries to offer its customers operational benefits when they start using EDI. At this side, CTO has to deal with a large number of small organisations, which explains why the introduction of EDI takes more time than at the sea-side. In the relation with large organisations which have their head-office elsewhere, CTO depends on the priorities which are set by that organisation and which can hardly be influenced. The standardisation circuit is used to prevent that large customers place stringent demands on CTO.

**IT importance**

CTO tries to achieve a certain level of efficiency and effectiveness. The processes depend very much on the quality of information exchange to reach those levels of efficiency and effectiveness. Use of EDI is thus seen as a logical step. For CTO effectiveness is a higher objective, which needs
constant improvement. CTO usually has a clear picture of the end situation which must be reached, but unfortunately the steps towards this end situation are often unclear. These steps should not be too large because it is impossible to grow from the current situation into the new situation in a single step. Both the internal organisation as well as the partners should be clearly informed why certain steps in a certain direction are made.

Projects are proposed and assessment is done based on the required budget. Every year, budgets are determined by the board of directors. They judge the budgets and receive recommendations out of the organisation. An overview of the projects is made and proposed to the board of directors. The board approves projects which can be executed in the upcoming year. When the board decides to cut in the budgets, the proposals are sent back to terminal management, who decides which project should be realised first. First, the content of the projects are judged, next priorities are determined and then it is determined whether the required resources are available. Priority setting is based on the organisational strategy. A basis is formed by the projected amount of containers to be handled versus the amount which is currently handled.

In the decision process on EDI projects, criteria used are customer service and product quality. Performing a cost-benefit analysis for EDI is simple. For example, when a ship needs to be loaded with 1000 containers and a human being can register 100 containers per hour at the bill of lading, it would take 10 hours per ship. This is too expensive and takes far too much time for a continuously working organisation. As such, the use of EDI will always turn out positive. Besides these direct advantages of EDI, CTO tries to take account of new possibilities and business redesign. In doing so, the benefits of EDI turn out even more positive. Another advantage of the use of EDI and the generic approach chosen is that electronic communication with other relations, such as banks, governments and suppliers also becomes easier. A disadvantage of the use of EDI is the vulnerability and decrease in flexibility: when a certain (external) network breaks down, the information flow stops, directly hampering the operational process.

Results and further developments
In the introduction of EDI, CTO was confronted with many problems which were not expected. At first, the existing IT infrastructure was not suitable to EDI. Next to that, terminal management did not support the necessary investments. In the market, EDI was not really an issue, making it difficult to convince management of its use. Other problems related to lack of technical and organisational alignment within the organisation. External problems stemmed from different priorities set by customers to whom CTO depended. Despite agreements, organisations were very slow in
adjusting to EDI-use. Technical issues were also difficult to solve with external partners and often very elementary information could not be given. All these problems are mainly caused by the fact that CTO clearly played the role of initiator. Despite these problems, CTO thinks that it could not have reached the position where it is now if it had not taken on the role of initiator. It prevented CTO from being surprised by messages developed elsewhere. CTO feels that decision-making is a very slow process. It has taken care of that issue internally, but inter-organisational decision-making remains slow. The same account for decision-making by governmental agencies, especially when compared with the harbour of Singapore.

When looking back at certain decisions, CTO would have done things differently now. Development of the EDI handler and servers would no longer be done in-house. This is also caused by the fact that currently much standard EDI hardware and software can easily be.

Given the experience with agreements with partners, CTO would appreciate the use of a memory to support decision-making. This can help to remember which party suggested what requirements at a certain moment and forgot later on in the process. It would also enlarge commitment of organisations involved. By properly documenting the steps taken in the decision process, transfer from information between employees across time will be easier. For the development and assessment of alternatives, especially for infrastructure, CTO would probably make use of investment graphs when they exist and are easily in use.

**The case of building material producer BMP**

This case describes the decision process on the introduction and use of EDI within a building material producer, which we named “BMP”.

**BMP and its environment**

BMP is a producer of building materials. BMP produces autoclaved aerated concrete, both for the construction industry and for the DIY-market. It is produced in various formats, according to principles of modular design. BMP owns and operates 24 continuously working plants and is active in 19 countries. The holding is located in Germany. World-wide BMP employs 2900 people, in the Netherlands approximately 500. The Dutch branch consists of a head office, three mills and a factory producing glue. The Dutch turnover is f130 million, world-wide turnover is DM 867 million. The main customers of BMP are trade organisations in building material, building contractors and construction industry, large chains of DIY-markets and purchase alliances of smaller DIY-markets. BMP has several
competitors, mainly determined by the use of material, such as steel and plaster. Because of their bulkiness, most raw materials are delivered at the mills by water. The suppliers of BMP are large. The environment of constantly changes: the markets, legislation (with regards to working conditions and the environment), introduction of the Euro-currency, year-2000 problems, etc.

BMP uses for its office automation a Windows-suite and Lotus Notes. The introduction of Notes was initiated in the Netherlands and became possible when a new network was implemented. On its turn, the new network became possible when the new head office was built. The production (equipment) is centrally steered and controlled from the office through a glass-fibre link between the office and the mills. Within the mills, Supervisory Control and Data Acquisition systems steer PLC’s (logic controllers), which on their turn steer the production processes. This set-up is intended to eventually support JIT-production (of made-to-order products). The objective for EDI-use is to support the path towards JIT.

The decision process

The decision process at BMP is executed along the line of the ‘foolproof’ method of Cap Gemini. This approach exists of the stages problem analysis, objective setting, alternatives generation and advice to management, and finally, a choice is made. Setting objectives is seen as the most important aspect of the decision process. BMP has a business plan from which operational plans (such as for IT) are derived. The IT plan has a horizon of one year and IT projects stem from this plan. The plan also determines IT budget, which mainly aims at maintenance and control. Budget determination takes place on the basis of results of the previous year and expected developments. Expectations are related to organisational growth and clear changes in the environment (such as the Euro-currency and the year-2000 problem). The budget is fairly constant.

Ideas regarding the use of EDI developed in 1990, as a result of EDI developments in the transport sector. A stimulus for the introduction of EDI within BMP was the fact that subsidies were available. Via the EDIBouw foundation, an initiative of several suppliers and building constructors, several EDI messages are defined and information exchange started using a stand-alone workstation via a Memocom mailbox. Processing of messages was done manually, which made the system more or less of an advanced fax. It did work, but did not lead to the advantages which could be expected from EDI. Another foundation, HCP started a comparable project aiming at EDI exchange of building material wholesalers. The two foundations served conflicting interests and BMP had interest in both developments. By putting pressure on the foundations (also by other
stakeholders), the foundations merged. Many parties have since then joined
the EDI community, but BMP feels that the amount of messages exchanged
is too low. Many parties initially agreed to join the EDI exchange, but step
out during implementation for all sorts of reasons. Because BMP was
initiator, several problems were encountered which now no longer exist.
For example, now standards exist to which everybody complies. On the
other hand, the role of initiator delivered a lot of free publicity and
supports a positive image of the organisation.

The main reason to start the EDI project with large partners was the
possibility of cost savings for all parties. Other reasons were the possibility
to quicker send information and to be more quickly informed. This, on its
turn, makes it possible to better steer and control stock which brings JIT
production in sight. Production can be better planned and lowering of stock
saves money. Tying customers to the organisation was another reason for
the project. Several unexpected effects occurred. For example, a good and
fruitful co-operation with partners, leading to long-term relations. Because
the partners also invested in the project, they would not quickly withdraw
from the project. All partners felt a clear win-win situation. BMP mainly
works with bilateral EDI exchange. The first stand-alone solution gave
insight into the possibilities of EDI, but was not suited for use in an
operational environment with growing information flows. Therefore, an
EDI application was built in-house, according to the existing standard.

The project was executed in association with two purchase alliances.
They were selected on the basis of a priority listing. Priorities were
determined on the size of the information flow. BMP strives for 100% EDI
exchange, but does not expect to completely realise this. For smaller
customers there will remain a separate information flow. Yet, because many
small organisations are taken over by or join in larger groups, more
organisations will eventually make use of EDI exchange. Because not all
organisations are involved (yet), not all benefits from complete EDI
exchange can be reaped. The use of EDI works positively for the
organisational image and BMP's marketing department explicitly mentions
it in its contact with the customers.

BMP made a cost-benefit analysis of the projects, in which all
quantifiable benefits were worked out in a five year plan. On that basis, the
payback period could be determined, which turned out to be 2 years. By
analysing the costs and benefits, BMP regarded the business processes at a
chain level. The non-quantifiable benefits were taken into account, but the
decision was made on the basis of the financial analysis. The financial
benefits were higher than the costs. BMP would like to be able to make the
non-financial benefits quantifiable as well. For investments BMP usually
takes a payback period which is a short as possible; about 1,5 years. For the
EDI investments this requirement was not that tight, because of the non-
financial benefits such as the promotional value, and because the partners were willing to invest as well. Common criteria used for investment assessment are payback period, support of the business processes, improvement of information exchange and customer service. Besides, BMP has a ROI target of 15%.

New projects stem from ideas generated within the organisation, customer demands and environmental developments, such as the availability of new technology. Within the organisation it is mainly the organisation & IT department which studies possibilities to improve the business processes by means of IT. Development of software used to be done in-house. For specific problems, external software suppliers were consulted. Currently, BMP makes use of standard software were possible.

The EDI project was split up in two stages: a decision stage and an organisation stage. In the decision stage, first a plan was developed to come to a plan of co-operation with external partners. All aspects related to co-operation were described. The plan was presented to management (which takes all ‘go/no go’ decisions), which approved it. In a second step, the plan for co-operation with partners was developed and presented to the targeted partners. The partners were responsible for 30% of the external information flow of BMP. In several sessions, the partners were convinced of the use of EDI. BMP asked them to sign an agreement for co-operation, to prevent the parties from withdrawal during the cause of the projects when BMP would already have invested. BMP wanted all parties to gain from the project and, as such, expected that all parties supported it. After this step, a project proposal was written and approved by management. The next stage was that of realisation, in which a pilot project was executed. Then, implementation and consolidation took place. After those steps, an evaluation stage was executed to find out whether the estimated results were actually realised. Then acquisition of new partners started. All aspects which were related to the project were covered in separate project teams (supported by the HCP/EDIBouw foundation). The teams delivered several reports which gave a structured insight into the consequences of investments in EDI. The groups operated in parallel and attained their results in approximately three months.

Results and further developments

An unexpected effect of the use of EDI is the improvement of co-operation with the partners. By jointly working at a project, a bond evolves, creating new possibilities for further co-operation. During the acquisition stages BMP noticed that most organisations are very enthusiastic at first, but during the course of implementation are confronted with all sorts of problems within their organisation, leading to lowering the priority of information exchange through EDI with BMP. BMP itself prevented these
problems by first analysing the business processes. Currently, BMP often gets requests of organisations to jointly start EDI projects. The innovative image of the organisation is of influence here. Eventually, EDI will serve to steer the production process (via the order process) of the made-to-order products. Too large a dependence on EDI is not expected.

BMP learned that projects can have difficulties when communication between developers of IT and users of IT is not properly taken care of. The developers need to communicate very clearly what they are about to develop and prevent a technology push approach. If users are not involved in the development they are hard to convince of the need of the product for their work and show a tendency to refrain from using it. For large projects this can be overcome through the involvement of the holding.

Within the decision process, BMP would like to have support for the quantification of the benefits, especially for the ones which are difficult to express in money. Support of the alignment of ideas of those who propose projects and those who make the decisions is also necessary. Management must be able to understand what the proposed projects imply and why they are important to the organisation. The line of reasoning is clearly different between the two groups. Because a multi-disciplinary approach towards problem solution will become common practice within the organisation, many activities will be executed in the form of projects. This calls for experience with project management.

When presented in a user friendly manner, BMP would use investment graphs. Such graphs would be particularly useful in convincing the traders in building material of the usefulness of EDI. A tool which can prove the advantages of EDI and can be used by the HCP/EDIBouw foundation as a service towards its members would certainly have an added value in this sector. A memory (for example in the form of a database) to support decision-making would be used within the BMP organisation. A database makes searching for information possible and easier than searching in a traditional archive. It would even be possible to eventually use the database to share information with partners.

The case of travel group TG

This case describes the decision process on a new IT strategy within a travel group, which we named “TG”.

TG and its environment

TG is an independent operating travel organisation and is part of a holding company. The holding company has two other daughters: a travel
organisation in the USA and an independent IT organisation which offers IT products to the travel branch. TG is divided in two business units. One is aimed at the tourist sector and employs about 250 persons at 83 travel shops spread throughout the Netherlands. The other unit aims at the business traveller and employs close to 150 persons at 17 locations. This latter unit can be further sub-divided in 'general' shops where every business traveller can book trips, and 'in-plants': travel agencies of large companies which are managed and operated by TG. Both business units have the same share in turnover of TG. Besides these business units, TG recognises several staff functions at the corporate level: HRM, quality management and IT. The head office employs approximately 90 persons.

TG makes a clear distinction between suppliers for business trips and for tourism. For tourism the suppliers are mainly tour operators. Some tour operators are both competitor and supplier, while they operate travel shops and supply their services to TG. For business travel, TG has a relationship with airlines, hotel chains and car rental companies. Nowadays, these business travel products are also sold to tourists and TG envisages a shift from standard packages towards the situation in which the tourist combines its own package of demands into a travel product. This places more emphasis upon the advisory function of TG. As a result, the typical division between business travel and tourism disappears and the product assortment becomes broader. At the same time, another shift takes place. Currently the travel agent is paid by the supplier on the basis of a commission and volume sold. Yet, suppliers find this construction too expensive. They put pressure on the travel agencies to become a trade partner, which buys travel products, adds certain value (for example, information) and determines on that basis a selling price for which the products are sold to the customer. This implies a shift of 180 degrees by travel agencies for the generation of income. TG already feels this pressure in business travel (the situation is already common practice in the USA). By means of Activity Based Costing, TG tries to find out whether and how different products can be determined and whether a cost price for those products can be established.

In the tourist market TG is the sixth largest organisation with regards to turnover, in business travel TG occupies a shared second place. The increase in turnover over 1997 was 70%, mainly by acquisition of smaller chains of travel shops. The market hardly grows, which makes it necessary for smaller organisations to find shelter in a larger group, given the expected dynamics of the future. Competition in the tourist market takes place at a national scale, competition in business travel has an international character. In business travel a clear trend is the necessity to fully service the traveller at a global scale. More and more customers are working at an international level and expect international service. This demand can be fulfilled by offering good service to the traveller and by giving clear
management information to the company. The need to offer global service was the main reason for TG to join the holding. Moreover, its American partner has a good coverage at the American market and the culture of both organisations are in alignment.

The unification of the European market makes it easier for the holding to further expand. TG just finished a plan to cope with the year-2000 problem. The Euro-currency has the same advantages and disadvantages for TG and its competitors. TG (and other travel organisations) encounters problems caused by the guidelines as stated by IATA for the airline industry. Those guidelines are a hindrance in the use of new technology. For example, the guidelines oblige travel agencies to register the tickets in stock while they currently obtain an amount of pre-numbered tickets. Given the new technological possibilities to set up and run systems, this guideline is completely outdated. New telematics applications make a better, more reliable approach possible, accompanied by savings on administrative expenses. TG notices that the IATA has problems in keeping up the pace in new areas. Even airlines sometimes decide to bypass IATA regulations to make agreements with large customers.

At this moment, several reservation systems are active on internet. TG is able to implement such an application, but because its customers have not asked for it yet, TG decided to wait. Besides, current systems at internet are limited to products which are available through Central Reservation Systems (CRS). Although those CRS cover about 90% of the entire product assortment, specific services, especially those requested by business travellers, are not covered.

For accounting and personnel administration, TG uses a standard package. For making reservations, TG uses the CRS Galileo (although a switch to Worldspan will be made). For tourism, TG uses Travelnet, a Dutch product, in which several tour operators offer their products. As such, Travelnet more or less works like a CRS. Next to that TG uses Intas, an administrative system for business travel.

The decision process

Until recently TG had a top-down decision process in which management took all decisions on investments. Investments were done in activities of which management thought it could be useful for the organisation. No extensive cost benefit analyses were performed. That approach was possible because the organisation used to be relatively small and an overview was easy. Currently, the approach towards investment decision-making becomes more formal, but TG is only at the brink of the changes which will have to be executed. The decision process should have clear steps in which first the
objectives are determined, next alternatives are generated, then an
assessment is made which can lead to choice.

Although the market is very dynamic and it is hardly possible to look
further than a year ahead, TG foresees a clear picture of its own future. It is
not written down, but TG’s aim is to become the number 1 in business
travel and to grow significantly in tourism. TG recognises the importance
of the use of new technology to reach those objectives. In 1997, TG executed
a small project which clarified the importance of the use of technology. In
the months which followed that project, TG has worked out the
consequences for the organisation of the vision stated in the project. The
project was initiated and sponsored by the IT department, but currently not
only has an IT part, but also a very large organisational part. IT management
has convinced management that fairly large investments in IT are necessary,
but that at the same time ideas from operations should be aligned with the
investments, to prevent investing in nifty applications which will not be used.

Estimation of the benefits of the planned IT investments relate to
cutting back administrative time by 50% at the tourism travel shops and an
improvement in administrative efficiency of 25-40% at the business travel
shops. The resulting benefits are divided by the estimated investments and
the payback period is determined. Including some risk-prevention, the
payback period still is very short: about 1,5 years. Because of the dynamics
at the travel market and IT market, TG has a very tight payback restriction
of 2 years. In the decision to change from CRS Galileo to Worldspan, TG
offered to deliver the network service and as such take responsibility for a
part of the operational costs. However, by investing in a new network
necessary for the CRS services, TG can also provide new functionality,
which on its turn can deliver new benefits. By coupling the switch of CRS
to the IT investments, a quick generation of benefits is linked to in-depth
investments. By constantly presenting the benefits of the investments to
management, IT management is able to step by step execute the necessary
investments. It is essential to make clear why certain investments are made
and how they are justified. In every next step, each investment must be
analysed further to clearly show its benefits (savings). It is not very difficult
to state in qualitative terms what the benefits of the investment will be. Yet,
the corporate controller wants to see those qualitative benefits expressed in
financial terms.

Given the dynamics at the market, TG searches for generic IT solutions.
If the investments are not placed in a generic context, the organisation
bears the risk that the product of the investment quickly becomes obsolete.
Currently, TG does not co-operate with suppliers to mutually invest in IT
support of information exchange. For standardisation of information
exchange, a project has started in which tour operators, CRS and customers
jointly try to come to exchange standards before the year 2000. Currently, standards are only available at specific areas of information exchange.

TG has a reputation of creating good and innovative ideas. That image should be maintained and further exploited. At the moment TG is equally good as other travel agencies, but finds this qualification unsatisfactory. It therefore strives for more body, international expansion and technological innovation.

Ideas for change and improvements of the organisation stem from all part within the organisation, because the employees have a good sight at market developments. Besides, the expansion of the organisation leads to an inflow of new employees with a different and fresh view at the organisation. TG finds itself between the demands and requirements of both its suppliers and customers. To prevent too large an influence at the organisation, TG tries keep suppliers and customers outside the (IT) border of the organisation as much as possible. TG has a clear picture of its IT needs. The IT market is scanned for available products, several specialists study the products, TG investigates whether the product is broadly used and whether the organisation which offers product is solid. Then, alignment possibilities with existing products are investigated and finally a decision is made.

Execution of the proposed steps in the plan mentioned above will take place in 1,5 years. TG has an IT budget which is split up in a part for operational support and maintenance and a part for the execution of the plan. The main criterion at which technology investments are assessed is the functionality which is offered. TG does not want to make concessions at the functionality which is necessary. To prove that the projected benefits are actually realised, a good measure should be available. That measure should come from the business units.

**Results and further developments**

The first months of the execution of the plan are used for the technological foundation, i.e. the new infrastructure. In the last months, TG will focus upon the new services and products which can be offered on the basis of the new infrastructure. Until now, all investments are realised within the budget, but this takes serious effort. TG currently lacks good project management, which sometimes leads to discrepancies between agreed targets and their actual realisation. TG should prevent that all organisational changes are triggered by IT investments and take place under the control of IT management. To overcome this problem, a future approach can be the outsourcing of parts of IT. Interaction between management and the people who determine IT functionality is very important. This requires methods which are user-friendly.
TG has learned that IT suppliers should not have too much freedom in the definition of requirements, because then the organisation is confronted with unwanted functionality. Therefore, TG tries to prevent to involve suppliers when its own ideas are not completely worked out. Within the implementation trajectory it is very important that management of the business units is urged to take the necessary redesign steps. TG needs external support for further implementation of the plan and training within the IT organisation is also necessary. Next to that, co-operation between travel agencies with regards to IT development is necessary while these developments require a solid foundation in the sector. Furthermore, changes need to take place at a controlled pace. First, small projects need to be executed and then larger ones. It is also necessary to make somebody responsible for the control of methods and means which can be used to justify investments. TG searches for a method by which agreed upon expenses and estimated benefits can be further detailed in the course of implementation. TG would certainly use a memory which saves the different steps taken in the decision process, decision criteria and expected costs and benefits, mainly because it is important for the continuity of projects. TG would also use investment graphs when they offer insight into dependencies between investments and enable the projection of future investment trajectories.
The FIM, decision trees and options

The FIM makes use of concepts developed in option theory and resembles decision trees. It makes use of the decision tree feature to express alternative investments and the option theory features to delay choices and to value series of dependent alternatives. In this appendix we make a comparison between the FIM and decision trees and option theory to highlight the differences and the features shared.

The FIM versus the decision tree

A decision tree can be used for decision-making under uncertainty. It enables decision-makers to decompose a large complex decision problem into several smaller problems (Winston, 1994). A decision tree is created to determine optimal decisions. This usually takes the form of maximising expected revenues or expected utility for the decision-makers. Decision tree analysis involves building a tree representing all possible states of the world and the decisions which can be made by decision-makers in response to them. To value a decision tree, decision-makers have to calculate expected cash flows based on their objective probability and then discount them at some chosen discount rate (Copeland and Keenan, 1998a). Decision trees can be constructed with decision forks and event forks. A decision fork represents a point in time when the decision-makers have to make a decision. An event fork is drawn when outside forces determine which of several random events will occur. Each branch of an event fork represents a possible outcome, and the number on each branch represents the probability that the event will occur. The event forks indicate that there are several (future) states of the world and that different states result in different payoffs to the decision-makers. If no forks emanate from a particular branch, that branch in the decision tree is a terminal branch (Winston, 1994).
An example of a decision tree is given in Figure C 1. The decision tree represents a situation in which TG has assets worth of 15 and want to determine whether to invest in new IT infrastructure, services and products to maximise the organisation's asset position. TG recognises three alternatives:

- Invest in a CRS switch and perform a pilot infrastructure project in a number of the travel shops. Then utilise the results of this pilot to determine whether or not to invest in full scale implementation.
- Immediately (without a pilot) invest in a full scale new IT infrastructure and CRS switch for the entire organisation in the Netherlands.
- Immediately (without a pilot) decide not to invest in a full scale new IT infrastructure.

In Figure C 1 estimates by the decision-makers are given on the probabilities of success or failure for the pilot, success or failure of full scale implementation of a new IT infrastructure and estimates of the revenues. In the case of success, 30 will be generated, in the case of failure, a loss of 10 is expected. The expenses for the pilot are 3. To determine the optimal decisions in a decision tree (in this situation: maximising the expected final asset position), the tree is 'folded back' from right to left. At each event fork the expected final asset position is calculated and entered into the 'O'. At each decision fork the '11' denotes the decision that maximises the expected final asset position, which is entered in the '□'. The entire decision tree is traversed back until the beginning of the tree. The optimal sequence of decisions can be obtained by following the '11'. Traversing through the decision tree of Figure C 1 in this fashion teaches us that the optimal set of decisions is to perform no pilot and then to invest in full scale implementation, leading to an expected final asset position of 27.
Conceptual difference

Although they have similar appearances, FIMs differ from decision trees. A decision tree represents the decomposition of a large decision which decision-makers currently face into alternative decision paths. As such, decision trees summarise all possible situations and the decisions decision-makers can make in response to them. The FIM relates interdependent investments in time. These investments are all new, optional, situations. They allow for a sequenced set of decisions, which do not have to be taken at once.

This main difference implies that the nodes and arrows/forks of a decision tree and a FIM should be interpreted differently. The nodes in a decision tree either represent a choice or an event. The FIM does not have event nodes describing external conditions. The alternatives described by the nodes are constructed taking into account expected external conditions. In decision trees, probability (functions) are associated to the forks, while impact of events can be represented in the FIM by associating probability functions with the effect values. The nodes in the FIM are based on knowledge of the decision-makers and equally plausible scenarios of the future.

The arrows in the FIM do not represent choices or events, as in the decision tree forks, but a migration path towards the new alternative. Migration costs are associated to a migration path within the FIM.

Other differences

A FIM is generally not a tree. A node in a FIM can have several inbound arrows, indicating that the particular investment can be arrived at via various paths. See also Figure C 2 in which nodes 4 and 5 can be arrived at from different starting points.

Figure C 2 A FIM

This brings another difference under consideration. The nodes in a FIM describe alternatives, which are complete new situations in which the investment is implemented. The FIM does not necessarily represent all possible alternatives.
Contrary to decision trees, the FIM does not use the concept of the terminal branch which represents a particular end-state. The FIM can be extended at will and (parts of) it can also be re-used again in new decision cycles.

**Resemblances**

In the decision tree of Figure C 1, the situation of not investing is taken into account. The FIM also recognises the non-investment situation, but more explicitly by using the base case (node B in Figure C 2).

**The FIM versus option theory**

The theory of real options is developed as a means to take the value of future alternatives into account which become possible by the alternative under consideration (see Dos Santos, 1991; Leslie and Michaels, 1997; Copeland and Keenan, 1998a, b; Luehrman, 1998a, b and chapter 5). It is an addition to traditional financial analysis, which assumes that decision-makers once make an irrevocable decision on investments, which are then passively hold. Option theory assumes that decision-makers can respond flexibly to new information and adjust their decisions. By taking into account the value of new information, a trade-off can be made between immediately making a decision or delaying the decision and nurturing the option. Deferral of investment decisions leads to two additional sources of value:
- The time value of money on the deferred expenditure.
- The value derived from changing circumstances.

Option theory is an approach for quantifying these two additional sources of value. As presented in chapter 5, within option theory, the NPV of a business proposal is thus determined as: $\text{NPV (entire proposal)} = \text{NPV (alternative under consideration)} + \text{NPV (future alternative(s))}$. This approach makes it possible to financially value a sequence of investments. The phase two assets comprise the option. When a certain investment is executed, it generates the options, which on their turn, when exercised, generate new options, etc. This sequenced structure of options enabling options (which may follow) is referred to as compound options (cf. Copeland and Keenan, 1998b), see Figure C 3. The concept of the compound option recognises the fact that anything that enhances the value of the option, enhances the value of its predecessor, because the value of the option forms part of the underlying asset value of its predecessor (cf. Luehrman, 1998b). This structure of compound options is also used within the FIM.
Conceptual difference

Despite the use of concepts from option theory, the FIM differs from option theory at several aspects. Next to the compound options, the FIM allows for competitive options. These are mutually exclusive options made possible by their predecessor in the FIM. This is represented in the FIM by two (or more) arrows leaving from one node, indicating the mutually exclusive destinations (see Figure C 3). Hence, investment 1 in Figure C 3 enables either investment 4 or investment 5. In this respect, the FIM differs from option theory. As a consequence, assessment within COMET should be performed differently than within option theory, because the values of competitive options should be taken into account.

Other differences

The fact that the FIM allows for competitive options implies that the assignment of option values to the alternatives at hand should be done contains extra steps over real option valuation. Assigning the estimates to the alternative at hand is done by collapsing effect values of competitive values (assigning and combining the estimates when different paths meet). Next, the FIM is folded back, taking uncertainties in account wherever applicable. Option theory also folds back, but does not contain a collapsing step.

Resemblances

As given in the introduction of this subsection, the FIM uses the feature of delaying decisions as introduced in option theory. As a consequence, the FIM also recognises the possibility of discarding option values less than zero (while there is no obligation to choose options, negative options can be left out). Yet, option theory only takes one financial value into account, whereas a FIM contains values of multiple effects. When a certain effect value is negative, this does not necessarily mean that the entire option is discarded, while other effect values may be positive.
Summary

The differences between the FIM, option theory and decision trees at the conceptual level are summarised in Table C 1.

<table>
<thead>
<tr>
<th>Aspect of the concept</th>
<th>FIM</th>
<th>Decision tree</th>
<th>Option Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decisions under uncertainty</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Make use of options</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>• Make use of new information</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>• Choice delay</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>• re-use of frame (FIM, tree or compound options)</td>
<td>yes</td>
<td>no</td>
<td>possible</td>
</tr>
<tr>
<td>Competitive options</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Besides the conceptual differences, there are also other differences, as well as shared features between the FIM, option theory and decision tree. These are summarised in Table C 2.

<table>
<thead>
<tr>
<th>Other aspects</th>
<th>FIM</th>
<th>Decision tree</th>
<th>Option Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes are alternative situations</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Several incoming arrows in a node</td>
<td>yes</td>
<td>no</td>
<td>no (possible)</td>
</tr>
<tr>
<td>'folding back' approach</td>
<td>yes</td>
<td>yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Explicit base case</td>
<td>yes</td>
<td>no</td>
<td>No</td>
</tr>
</tbody>
</table>
Summary

Currently, telematics developments seem to follow the speed of light. Companies are continuously confronted with the new opportunities and threats associated with the telematics developments. An important question which needs to be answered is what useful contribution telematics developments may have for the business processes. To put it simple: what offers telematics in terms of costs and benefits? Gaining insight into the telematics contribution appears to be difficult in practice.

Telematics investments have several aspects which make the assessment and investment-decision difficult:

- The technological developments follow each other in a rapid pace, while the life cycle of the technologies seems to shorten. Besides, we do not have a real ‘telematics history’, making it hardly possible to rely on earlier experiences.
- Another aspect is that telematics investments usually are not implemented in isolation, but are part of a complex set of investments, making it difficult to assess the individual contribution of telematics.
- Next to that, telematics is often an integrated part of business processes and as such has not a form to evaluate it as an entity in the organisation, set apart from other entities.
- In addition, part of the costs and benefits cannot be directly expressed in quantitative (preferably financial) terms, but have to be expressed in qualitative terms.
- Moreover, telematics investments often cross the border of organisations, making it difficult to pinpoint its contribution, but also to identify where the costs and benefits in a chain will occur.

The different aspects are also present for other investment decisions (think of the development of new products). The difficulty for telematics investment decisions is that these aspects often occur all at the same time.
In this book we try to obtain insight in the reasons which make the telematics investment decision a tough job. Our objective is to generate a set of starting points and requirements for a methodology which can support decisions on telematics investments. We present a first design of a methodology that is based on the derived requirements. We named this methodology COMET.

The approach taken

This book consists of three parts, which also reflect the steps we have taken during the research.

We first analysed the basis of the problems which are related to telematics investment decisions. Insight in the problems renders the requirements which need to be fulfilled by a methodology aimed at decision support. The steps in the research we followed, as well as the results are described in the first part of this book, covered by chapters 2-6. This explorative research consisted of an exploration of decision theory (chapter 2) to gain insight into decision processes. To find a solid theoretical basis for the methodology, we analysed welfare economics and transaction cost economics (chapter 3). Next, we studied existing problems related to investment decisions in practice by analysing six existing cases on EDI-decisions (chapter 4). After that we made an inventory of existing methods to support telematics investment decisions and analysed their advantages and disadvantages. An extensive overview of methods supporting the different stages of decision-making is given in chapter 5.

The chapters 2-5 rendered a large set of requirements at which a methodology can be based. To validate these requirements, we analysed four new cases. The organisations that co-operated in the research are a large transport company, a container terminal operator, a producer of autoclaved aerated concrete and a travel organisation. The results of this activity are described in chapter 6, which also summarises all requirements for a methodology. Appendix A contains the interview scheme we used for the cases and appendix B gives the summarised interview reports of the respective companies.

In the second part of this book the methodology is presented. After an overview of the general aspects of COMET in chapter 7, chapters 8-11 describe for each stage of the decision process how the methodology works and how the decision-makers can use it. In this part of the book we introduced a running example in which a travel organisation is deciding on
new telematics. For each of the stages in the decision process the example shows how the methodology can be used.

Part 3 contains the conclusions of our work. These conclusions are for a large part based on an expert session. In that session, all parts of COMET were discussed and the experts gave their view on the use, applicability and usability of the methodology. The experts came from business (respondents of the cases) and the academic world. After a general introduction of the methodology, all components of COMET were discussed using propositions.

Results

Our work generated two results: the starting points and requirements for the development of a methodology and a first version of the design.

The starting points

We analysed the model of the rational decision-maker, the model of the bounded rational decision-maker, the political decision model and the chaos model of decision-making. Based on this analysis, we have chosen the bounded rational decision model as basis, added with concepts of the political decision model. The decision model which serves as a basis for COMET has decision cycles and each cycle consists of four stages. The first stage is setting of objectives, the second stage generation of alternatives (solutions to fulfil the objectives), the third stage assessment of alternatives and the fourth stage is choice. The cycles are executed until a final choice is made.

In chapter 3 we analysed welfare economics and transaction cost economics.

We have chosen to analyse welfare economics because it explicitly discusses distribution of welfare. This analogy is important for the division of costs and benefits which cross the boundaries of organisations. The cost-benefit analyses in welfare economics are macro-economic analyses. It appears that almost all concepts are useful for telematics investments.

Transaction costs economics does not fundamentally conflict with welfare economics, but explains the economy from a different dimension, notably that of the transaction. This theory also contains concepts which are useful to base COMET on. Yet, the ‘transaction’, which is one of the central concepts, is difficult to use in supporting investment decision processes. We therefore make use of the cost-benefits concepts from welfare
economics as starting point for COMET. This leads to the following requirements. COMET should:
- Clarify the relation between objectives, between objectives and business processes and between business processes and telematics investments.
- Contain a method to perform cash-flow analyses.
- Clarify the effects to others stakeholders than the decision-makers and possibly internalise these effects.
- In addition to a financial cost-benefit analysis, offer possibilities to find and analyse qualitative effects.
- First assess the alternatives themselves and then compare them with each other and a ‘base case’. The ‘base case’ represents a prolongation of the current situation.
- Take all effects into account.
- Take net present value as a financial decision criterion into account.

The analysis of the cases in chapter 4 rendered the following results. COMET should:
- Support the different groups in a decision process by offering a clear structure and methods which all groups understand.
- Support clear transfer of information between the different stages in the decision process.
- Contain methods to perform SWOT-analyses.
- Contain a memory.
- Recognise that telematics investments are implemented in a phased manner, where latter investments are being made possible by earlier investments.
- Make several forms of alternative assessment possible.
- Suggest decision criteria or offer a structured method to derive the decision criteria from the objectives.
- Oblige a proper assessment of alternatives and offer means to set realistic objectives.

In chapter 5 we analysed existing investment decision support methods. This rendered the following results. COMET should:
- Within the stage ‘objective setting’ support the following activities:
  - Analysis of the organisation, the environment and the mutual relations.
  - Searching for situations for which telematics investments are useful.
  - Analysis of organisational performance from different perspectives.
  - Perform a more fundamental analysis (than current methods) of telematics effects.
Suggest mutual exclusive decision criteria which have a clear relation with the objectives and which allow for an assessment of all consequences of an investment.
- Suggest new methods for the generation of alternatives.
- Stimulate decision-makers to think of future possibilities of current investments and of future options.
- Support group decision-making and at the same time remain compact.

By means of four cases the requirements are validated. The cases did not lead to clear rejection of the requirements, although for several requirements no clear statements from the cases could be derived. Based on the results, the first design of COMET is developed along the lines of the decision process model.

The methodology

The main components and aspects of COMET are the following:

The methodology consists of four modules. Each of the modules supports one step in the decision process: support for setting objectives, generation of alternatives, assessment of alternatives and choice.

The different decision cycles make it possible to apply the so-called sieve and magnifying glass processes. By these processes the number of alternatives can be reduced (sieve) and certain chosen alternatives can be refined and split into new alternatives (magnifying glass).

The module to support objective setting contains:
- A SWOT-analysis, supported by scenario planning and the value chain and the five forces model of Porter. With these instruments the user can analyse the organisation (or organisational network) and the environment on strengths, weaknesses, opportunities and threats. The results can serve as starting point for setting objectives.
- A decision criteria checklist, based on the Balanced Scorecard, containing suggestions for criteria which can be used. To obtain a complete view on the effects of an investment, COMET suggests to use the criteria NPV, customer service, employee well-being, migration costs en agility.
The module to support the generation of alternatives contains:
- A ‘Future Investment Map’ (FIM) which takes into account future options which are enabled by the alternatives under consideration. Using the FIM makes it possible to explicitly take into account the future possibilities of current alternatives. By taking into account these options a better assessment of the alternatives under consideration becomes possible. This is particularly relevant for investments in infrastructure.
- A ‘Telematics Investment Classification Mechanism’ to categorise investments to support the deriving of telematics-effects. The mechanism is derived from the BPR-model of Venkatraman. It classifies investments in those focused on the structure of components (processes, organisations, networks) and those focused on the relation between components.
- A ‘Categorised Effects Framework’ to derive effects.
- Suggestions to determine the relation (function) between effects and criteria.

The module to support the assessment of alternatives contains:
- Suggestions to estimate and appraise the effects for the options and alternatives within the FIM.
- A ‘Complete Effects Scorecard’ containing all estimated effects.
- Rules to assign the values of the effects of the options to the alternatives. (by means of ‘collapsing’ and ‘folding-back’ the FIM). This activity renders a ‘Pulled-back Effects Scorecard’.
- By applying the functions of the effects to the criteria the Pulled-back Effects Scorecard’ is translated into a ‘Criteria Scorecard’.

The module to support choice contains:
- Suggestions to compare alternatives. This renders a ranking of criteria values on the basis of which a ranking of alternatives can be made.
- Suggestions on how to select alternatives.
- An overview of further steps that can be taken.

Next to the modules, the description of the methodology also gives suggestions for the development of a memory within COMET and the components that the memory should contain. These components are the above mentioned parts of COMET as well as the actual results of each stage in the decision process.
Further work

In this book we describe the requirements for and a first design of a methodology to support telematics investment decisions. By emphasising that we describe a first design, it is clear that more can and should be done. We here present three directions for further work: the theoretical foundations, COMET's use in practice and the way decision-makers can jointly make use of COMET.

The theoretical basis for COMET are the concepts of cost-benefit analyses from welfare economics. They are expanded and added with concepts from many other theoretical areas, most notably from organisation theory, theory on strategic management and option theory. Currently no problems are seen in the combinations of the concepts, but more in-depth research can be performed on the alignment of the different concepts used.

Next to that, COMET is suggested to be a framework out of which decision-makers can use methods, but also can add methods they prefer to use and which are currently not in the framework. Research can focus upon the possibilities on how to extent the methodology and which boundaries/limitations should be considered.

A first confrontation of the methodology with practice took place in a controlled situation. To find out the actual use of COMET, it has to be applied in practice, most likely by means of case research. Yet, at this moment, the methodology exists on paper. To actually apply it in practice it must be refined and made operational, probably via the construction of a tool on the basis of the first design, as suggested in the expert meeting. By applying it in practice the entire methodology can be tested: its structure, its components, the criteria and effects suggested, its ease of use, etc.

One of the suggestions made during the expert meeting is the development of a range of COMET versions, from a 'starter's package' to an 'expert version'. This may lead to quicker acceptance and use of the methodology. Research has to be performed on how to offer a range of COMET products, followed by research on use and usefulness of various COMET forms.

One of the generic requirements to COMET presented in chapter 1 is the need for an inter-organisational approach. Three issues were raised: inter-organisational co-operation, inter-organisational description of the investment and inter-organisational assessment of the investment. By using a process view, TICS and the HIM, COMET allows for the inter-organisational description and assessment. (Inter-organisational) co-operation is currently under-exposed with the methodology. Co-operation is obvious for
situations in which decisions on inter-organisational telematics investments should be taken. But also in intra-organisational situations, different parties can be present, for example when different departments or business units are involved. Though the decision process will contain various steps which ask for co-operation, each stakeholder will have specific considerations that he wants to take into account. Besides, it may be efficient to divide the work among the parties involved.

We therefore suggest to explore the possibilities to model decision-making at a high level as a ‘multi-zipper’ process. In this multi-zipper model, some steps can be carried out in co-operation, other in isolation. All modules within COMET can be used in both situations. Of course, more complicated situations (with e.g. more than two groups of stakeholders) are possible. By making explicit that certain steps are taken isolation and others in co-operation, the multi-zipper can be used by the decision-makers to structure, plan and trace their activities and for making their organisation-specific trade-offs within the decision process. Further research should indicate whether this form of process support is useful.
Samenvatting

Telematica-ontwikkelingen volgen tegenwoordig bijna de snelheid van het licht. Bedrijven worden continu geconfronteerd met nieuwe mogelijkheden en bedreigingen die de telematica brengt. Een belangrijke vraag die telkens moet worden beantwoord is welke nuttige bijdragen de telematica-ontwikkelingen aan de bedrijfsprocessen kunnen brengen. Eenvoudiger gezegd: wat levert telematica ons op in termen van kosten en baten? Het verkrijgen van inzicht hierin blijkt in de praktijk vaak problematisch te zijn.

Telematica-investeringen herbergen een aantal aspecten in zich die de beoordeling en investeringsbeslissing lastig maken:

- De technologische ontwikkelingen volgen elkaar in snel tempo op, terwijl de levensduur van dergelijke technologie steeds korter lijkt te worden. Daarnaast is er niet een echte ‘telematica-historie’ waardoor het bijna niet mogelijk is om terug te vallen op eerdere ervaringen.
- Een ander punt is dat telematica-investeringen vaak niet op zichzelf staan, maar onderdeel zijn van een complex van investeringen, waardoor de individuele telematica-bijdrage moeilijk is vast te stellen.
- Bovendien vormt telematica vaak een geïntegreerd geheel met bedrijfsprocessen en is als zodanig niet als een te evalueren entiteit in de organisatie te onderscheiden.
- Daar komt bij dat een deel van de kosten en baten niet direct kwantitatief, liefst in geld is uit te drukken, maar in kwalitatieve termen moet worden uitgedrukt.
- Verder overschrijden telematica-investeringen vaak de grenzen van een organisatie, waardoor moeilijk is vast te stellen waar de bijdrage ligt, maar ook waar de kosten en baten in een keten zullen ontstaan.

De verschillende aspecten op zichzelf komen ook voor bij andere investeringsvraagstukken (denk aan de ontwikkeling van nieuwe producten). Wat de beoordeling van een telematica-investering zo lastig maakt is dat alle aspecten zich vaak tegelijkertijd voordoen.
In dit boek proberen we meer inzicht te krijgen in de achterliggende redenen die het nemen van telematica-investeringsbeslissingen bemoeilijken. De bedoeling is te komen tot een verzameling uitgangspunten en richtlijnen voor een methodologie die alle aspecten van het besluitvormingsproces aangaande telematica-investeringen ondersteunt. We presenteren een eerste opzet van een methodologie die is gebaseerd op de afgeleide uitgangspunten. Die methodologie hebben we COMET genoemd.

De gevolgde aanpak

Het boek bestaat uit drie delen, die de stappen in het werk ook weergeven.

Eerst hebben we ons gericht op het vinden van de basis van de problemen rond telematica-investeringsbeslissingen. Inzicht hierin levert de eisen en wensen waaraan een methodologie ter ondersteuning van besluitvorming dient te voldoen. De gevolgde stappen en resultaten zijn beschreven in het eerste deel, bestaande uit de hoofdstukken 2-6. Dit verkennende onderzoek bestond uit een theoretische verkenning om meer inzicht te krijgen in besluitvormingsprocessen (hoofdstuk 2) en om een solide theoretische basis voor de methodologie te vinden. Daartoe hebben we in hoofdstuk 3 welvaartstheorie en transactiekostentheorie geanalyseerd. Vervolgens hebben we onderzocht wat reeds bekende problematiek rond investeringsbeslissingen in de praktijk oplevert. Daartoe hebben we zes bestaande cases over EDI-beslissingen geanalyseerd. Dit is beschreven in hoofdstuk 4.

Vervolgens hebben we onderzocht welke methoden er bestaan ter ondersteuning van telematica-investeringsbeslissingen en wat de voor- en nadelen van deze methoden zijn. Een uitgebreid overzicht van methoden voor de verschillende stappen in het besluitvormingsproces is beschreven in hoofdstuk 5.

De hoofdstukken 2-5 hebben een groot aantal uitgangspunten opgeleverd waar een methodologie op kan worden gebaseerd. Ter validering van deze uitgangspunten hebben we vier nieuwe cases geanalyseerd. De bedrijven waar we de analyse hebben uitgevoerd zijn een groot transportbedrijf, een container-overslagbedrijf, een producent van cellenbeton en een reisorganisatie. De resultaten van deze exercitie zijn beschreven in hoofdstuk 6, waar tevens alle uitgangspunten voor een methodologie zijn samengevat. Appendix A bevat het interviewprotocol dat we hebben gebruikt bij de cases en appendix B de uitgebreide resultaten van de gesprekken met de respondenten van de individuele bedrijven.

In het tweede deel van dit boek wordt de methodologie gepresenteerd. Na een overzicht van de algemene aspecten van COMET in hoofdstuk 7 wordt in
Resultaten

Ons werk heeft twee soorten resultaten opgeleverd: de uitgangspunten voor ontwerp van een methodologie en een daadwerkelijk ontwerp.

De uitgangspunten

Op basis van de analyse van het model van de rationele beslisser, het model van de beperkt rationele beslisser, het politieke model en het chaos-model hebben we gekozen voor het beperkt rationele model als basis, aangevuld met concepten uit het politieke model. Het model dat als basis dient voor COMET kent cycli en binnen iedere cyclus vier stappen. De eerste stap is het stellen van de doelen, de tweede stap het vinden van alternatieven (oplossingen voor de doelstellingen), de derde stap het waarderen van de alternatieven en de vierde stap betreft de keuze. De cycli worden net zolang doorlopen totdat er een finale keuze is gemaakt.

In hoofdstuk 3 analyseren we welvaartstheorie en transactiekostentheorie. We hebben gekozen voor welvaartstheorie omdat hierin expliciet aandacht wordt aan welvaartsverdeling. Deze analogie is belangrijk waar het gaat om verdeling van bedrijfsoverschrijdende kosten en baten. De kosten-baten analyses binnen welvaartstheorie zijn macro-economische analyses. Het blijkt dat bijna alle concepten bruikbaar zijn voor telematica-investeringen.

Transactiekostentheorie conflicteert niet fundamenteel met welvaartstheorie, maar beschouwt de economie vanuit een andere dimensie,
namelijk die van de transactie. Ook deze theorie bevat concepten die bruikbaar zijn ter onderbouwing van COMET, maar met name het concept ‘transactie’, één van de centrale concepten, is lastig te gebruiken om investeringsbesluitvorming te onderbouwen. Mede hierom nemen we de kosten-baten concepten uit de welvaartstheorie als uitgangspunt voor COMET. Dit leidt tot de volgende uitgangspunten. COMET moet:
- De relatie tussen doelen, tussen doelen en bedrijfsprocessen en tussen bedrijfsprocessen en telematica-investeringen verhelderen.
- Een methode om cash-flow analyses uit te voeren bevatten.
- Effecten voor andere belanghebbenden dan de besluitvormers duidelijk maken en mogelijk internaliseren in de beslissing.
- In aanvulling op een financiële kosten-baten analyse mogelijkheden bieden om kwalitatieve effecten te vinden en te analyseren.
- Eerst de alternatieven zelf waarderen en ze vervolgens met elkaar en een ‘base case’ vergelijken. De ‘base case’ representeert de voortzetting van de huidige situatie.
- Alle effecten meenemen.
- Netto contante waarde als financieel besliscriterium meenemen.

De analyse van de cases in hoofdstuk 4 leverde de volgende resultaten op. COMET moet:
- De verschillende groepen betrokkenen in een besluitvormingsproces kunnen ondersteunen door middel van een duidelijke structuur en methoden die alle groepen begrijpen.
- Duidelijke overdracht van informatie tussen de verschillende stappen van het besluitvormingsproces ondersteunen.
- Methoden bevatten om SWOT-analyses te kunnen doen.
- Een geheugen bevatten.
- Herkennen dat telematica-investeringen stapsgewijs worden geïmplementeerd, waarbij latere investeringen mogelijk worden gemaakt door eerdere investeringen.
- Meerdere vormen van alternatieven-waardering mogelijk maken.
- Besliscriteria voorstellen of een gestuctureerde methode aanbieden om deze criteria af te leiden uit de doelstellingen.
- Een goede waardering van alternatieven afdwingen en middelen bieden om realistische doelen te stellen.

In hoofdstuk 5 hebben we bestaande methoden ter ondersteuning van investeringsbeslissingen geanalyseerd. Dit leverde de volgende resultaten op. COMET moet:
- Binnen de stap ‘stellen van doelen’ de volgende activiteiten ondersteunen:
  - Analyse van de organisatie, de omgeving en de onderlinge relaties.
Zoeken van situaties waarvoor telematica-investeringen zinvol zijn.
Organisatorische performance beschouwen vanuit verschillende perspectieven.
Een fundamentele analyse (dan huidige methoden) van telematica-effecten plegen.
Onderling onafhankelijke beslisscriteria suggereren die een duidelijke relatie met de doelstellingen hebben en analyse van alle gevolgen van een investering mogelijk maken.
Nieuwe methoden voor de ontwikkeling van alternatieven suggereren.
Beslissers stimuleren na te denken over toekomstige mogelijkheden van de huidige investeringen en over toekomstige opties.
Groepsbesluitvorming ondersteunen en tegelijkertijd compact blijven.

Met behulp van vier cases zijn de uitgangspunten gevalideerd. De case leverde geen verwerping van de uitgangspunten op, hoewel voor verscheidene uitgangspunten geen duidelijke uitspraken uit de cases zijn te halen. Op basis van deze resultaten is de eerste opzet van COMET ontworpen langs de lijnen van het besluitvormingsmodel.

De methodologie

De belangrijkste componenten en aspecten van COMET zijn de volgende:

De methodologie bestaat uit vier modules, waarbij iedere module ondersteuning biedt aan een stap in een besluitvormingscyclus:
ondersteuning van het stellen van doelen, het genereren van alternatieven, het evalueren van alternatieven en het maken van keuzen.

De verschillende cycli maken het mogelijk om de zogenaamde zeef- en vergrootglas processen uit te voeren. Daarmee kan respectievelijk het aantal alternatieven worden verminderd en bepaalde gekozen alternatieven verder uitgesplitst worden in nieuwe alternatieven.

De module ter ondersteuning van doelen stellen bevat:
- Een SWOT-analyse, ondersteunt met scenario planning en de waardeketen en het vijf-krachtenmodel van Porter. Met deze analyse-instrumenten kan de gebruiker de organisatie (of het organisatorische netwerk) en de omgeving analyseren op sterkten, zwakten, kansen en bedreigingen. De resultaten kunnen dienen als uitgangspunt voor het stellen van de doelen.
- Een beslisscriteria-checklist, gebaseerd op de Balanced Scorecard met suggesties voor te gebruiken criteria. Om een compleet beeld van de gevolgen van een investering te verkrijgen suggereert COMET om gebruik
te maken van de criteria netto contante waarde, customer service, employee well-being, migration costs en agility.

De module ter ondersteuning van het genereren van alternatieven bevat:
- Een 'Future Investment Map' (FIM) waarin toekomstige opties die worden mogelijk gemaakt door de huidige investeringsalternatieven ook worden meegenomen. De map is gebaseerd op beslisbomen en optietheorie. Door gebruik te maken van de FIM wordt expliciet rekening gehouden met toekomstige mogelijkheden van huidige alternatieven. Door de toekomstige mogelijkheden in beschouwing te nemen is het mogelijk om te komen tot een betere waardering van de huidige alternatieven. Dit geldt met name voor investeringen in infrastructuur.
- Een 'Telematica Investerings Classificatie Mechanisme' om investeringen te categoriseren ter ondersteuning van de afleiding van telematica-effecten. Het mechanisme is afgeleid van het BPR-model van Venkatraman. Het maakt een onderverdeling naar investeringen met betrekking op de structuur van componenten (processen, organisaties, netwerken) en de relatie tussen componenten.
- Een 'Gecategoriseerd Effect Raamwerk' om effecten af te leiden.
- Suggesties om de relatie (functie) tussen effecten en criteria vast te leggen.

De module ter ondersteuning van de waardering van alternatieven bevat:
- Suggesties om de effecten voor de opties en alternatieven in de FIM te schatten en te waarderen.
- Een 'Complete Effecten Scorecard' waarin alle geschatte effecten zijn opgenomen.
- Regels om de effectwaarden van de opties aan de alternatieven toe te kennen (door middel van 'inklappen' en 'terugvouwen' van de FIM). Dit levert een 'Teruggevouwen Effecten Scorecard' op.
- Door toepassing van de functies tussen de criteria en de effecten wordt de 'Teruggevouwen Effecten Scorecard' omgezet in een 'Criteria Scorecard'.

De module ter ondersteuning van de keuze bevat:
- Suggesties om alternatieven te vergelijken. Dit levert een rangorde van criteria-waarden op, op basis waarvan een rangorde van alternatieven kan worden gemaakt.
- Suggesties voor selectie van alternatieven.
- Een overzicht welke verdere stappen kunnen worden genomen.
Naast de modules bevat de beschrijving van de methodologie ook suggesties voor de ontwikkeling van een geheugen binnen de methodologie en de componenten die een dergelijk geheugen moet bevatten. Dat zijn alle bovengenoemde componenten van COMET en de daadwerkelijke resultaten per stap in het proces.

**Verder Werk**

In dit boek hebben we de uitgangspunten voor en een opzet van een methodologie ter ondersteuning van telematica-investeringsbeslissingen gepresenteerd. Door te benadrukken dat het hier om een eerste opzet gaat, is duidelijk dat er meer kan en moet worden gedaan. Hier geven we drie richtingen voor verder onderzoek: de basis voor COMET, het gebruik en operationalisatie van COMET in de praktijk en inter-organisatorische samenwerking.

De theoretische basis van COMET wordt gevormd door de concepten rond kosten-baten analyses uit welfare economics. Die concepten hebben we aangevuld met vele andere concepten, zoals uit organisatie-theorie, theorie rond strategievorming en optie-theorie. Vooralsnog lijken er geen problemen uit deze combinatie voort te komen, maar een nadere analyse is hier op zijn plaats ter verbetering van de aansluiting van de verschillende concepten op elkaar.

Daarnaast wordt binnen COMET expliciet de mogelijkheid geboden om naast de methoden die er al in zijn opgenomen, nieuwe methoden toe te voegen. Verder onderzoek kan zich richten op de vraag hoe de methodologie kan worden uitgebreid, met welke methoden en welke randvoorwaarden of beperkingen daarvoor gelden.

Een eerste confrontatie van COMET met de praktijk heeft plaatsgevonden in een expertsessie, onder gecontroleerde omstandigheden. Feitelijke toepassing van COMET in de praktijk dient nog plaats te vinden. Een mogelijke aanpak daarvoor is case-research. Daarbij dient te worden opgemerkt dat COMET vooralsnog alleen op papier bestaat en dat het noodzakelijk kan blijken om er eerst een instrument (bijvoorbeeld een computerprogramma) van te maken. Alle aspecten van COMET kunnen worden onderzocht. Bovendien kunnen de uitgangspunten verder worden gevalideerd.

In de expertsessie werd geopperd om COMET als pakket aan te bieden aan de gebruikers, waarbij zou kunnen worden gedifferentieerd van 'starterspakket' tot 'expert-versie' ter bevordering van de acceptatie van de methodologie. Onderzoek kan zich richten op hoe een range van COMET-
producten kan worden ontwikkeld en wat het nut daarvan voor de praktijk zal zijn.

In hoofdstuk 1 is aangegeven dat een inter-organisatorische aanpak in de besluitvorming noodzakelijk is. Het gaat daarbij om inter-organisatorische samenwerking, inter-organisatorische beschrijving van de investering en inter-organisatorische waardering van de investering. De samenwerking is op dit moment een onderschoven kindje binnen de methodologie. Verder onderzoek kan zich richten op ondersteuning van deze samenwerking. Een voorzet hiertoe is de multi-zipper. Dit model presenteert het besluitvormingsproces als een serie stappen waarbij de verschillende belanghebbenden sommige stappen gezamenlijk uitvoeren en andere stappen in afzondering. Dit model kan behulpzaam zijn bij de verbetering van de efficiency van het besluitvormingsproces (verschillende activiteiten kunnen in sub-groepen parallel worden uitgevoerd) en bij de afwegingen die verschillende belanghebbenden afzonderlijk zullen willen maken. Nader onderzoek dient uit te wijzen of deze vorm van procesbegeleiding zinvol is.
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Background Material/Further Reading


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Comet
A comprehensive methodology for supporting telematics investment decisions
Roger Demkes

Telematics has proven to be a complex investment object, for which it is difficult to determine the costs and benefits.

This book presents COMET, a modular methodology for supporting decisions on telematics investments. It offers structure and guidance in setting the proper objectives, finding and assessing relevant investment alternatives and making choices.

COMET includes a Telematics Investment Classification Scheme and a Categorised Effects Framework, supporting the search for and estimation of the proper telematics effects. Next to that COMET provides Future Investment Maps, which allow for attributing costs and benefits of future options to current alternatives, thus enabling comprehensive assessment of the expected value of investments.

COMET contains extensive possibilities for analysing and comparing the expected results of different alternatives, thus offering a sound basis for making the right choices.