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Green Decision Making: How Systemic Planning can support Strategic Decision Making for Sustainable Transport Development

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Green Decision Making

How Systemic Planning can support Strategic Decision Making for Sustainable Transport Development

Steen Leleur

April 2017

The book is an extended and edited version of a working paper "Better Joint Decisions", SUSTAIN international research project, February 2015.

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Preface

The book is based on my participation in the SUSTAIN research project 2012-2017 about National Sustainable Transport Planning funded by the Danish Research Council (Innovationsfonden). Many of the issues treated here have a backdrop in my book *Complex Strategic Choices – Applying Systemic Planning for Strategic Management*. The book was published in 2012 by Springer-Verlag, London, as a research monograph in the publisher's series about Decision Engineering. The intention behind this new book – with its focus upon 'greening' of strategic decisions – is to provide a general and less technical description of the possibilities that *a systemic approach to complex planning problems* seems to offer.

As will appear, the presentation of systemic planning (SP) below is primarily based on applying SP to transport infrastructure investments. However, SP in its process and methodological outline should not be seen as restricted to this application area. In fact a company relocation decision case has been used to introduce the potential of SP as regards providing decision support for strategic decision making. A main concern in this presentation of SP, which deviates from the Springer book referred to above, is to highlight that 'greening' of decision making is not an 'add-on' activity. More likely it is a possibility that arises by basing complex strategic choices on decision support knowledge established by conducting and combining specific types of examination related to the actual complex decision problem, typically of strategic nature.

In brief the book aims at convincing its readers that:

SP can function as a highly practical and creative approach for 'green decision making', i.e. SP can facilitate the making of informed decisions that can contribute to sustainable transport development within the overarching goal of achieving social, environmental and economic sustainability.

The book starts with an introduction in Chapter 1 to the background of planning and its present meaning. A special view is given to planning in relation to complex decisions where these are seen as a challenge which has not become smaller during the most recent decade. Afterwards the idea of systemic planning is outlined.

The following Chapter 2 starts with a description of five different perspectives, each of which is of relevance for the assessment of a set of alternative, future-oriented choices. A basic element of SP is that these different perspectives – individually and in their interaction – can contribute to defining the most attractive choice of alternative. The process is set out by a formulated 'SP wheel' that drives the planning process forward until a decision or decision recommendation can be made. In the SP wheel focus is put on the possibilities of combining 'soft' and 'hard' methods from operations research (OR – applied mathematics for problem solving). The chapter ends with a number of considerations about how in the case of a concrete planning and decision problem by means of a group process we can establish the best possible knowledge basis with the purpose of making the best possible decision. In brief, such a basis can be referred to as decision support.

Chapter 3 presents some examples to illustrate the possibilities of using SP. First, an overview is provided by describing a concrete process about the strategic relocation of an international consultancy company in the Danish-Swedish Oresund Region. Afterwards, an example regarding a new fixed link between Danish Elsinore and Swedish Helsingborg illustrates, among other things, topics such as the importance of the socio-economic robustness of the decision weighed together with other strategic factors. Emphasis is here on SP and creativity. In the following example about the reconstruction of a railway line in the EU transport corridor

from Helsinki to Warsaw it is illustrated how SP can be used to promote a sustainable decision.

Overall, the final Chapter 4 looks at the challenges of planning by referring to the so-called 'white elephants' that symbolise failed projects and to 'black swans' that symbolise unforeseen major events. Hereby the robustness of the investment decisions comes into focus which is illustrated by means of an analysis in connection with a planned extension of the Nuuk airport, Greenland. In addition, various pitfalls and biased decisions which may result in bad planning and bad decision support are described. Together with the case examples in Chapter 3 this forms the basis of a final statement about the role that systemic planning can have as decision support.

In addition to the book's main text, Appendix 1 gives some details about learning in SP, and Appendix 2 similarly some details about modelling in SP. Both appendices are more technical than the text in the four chapters and could therefore be skipped by a reader with mainly a general interest in the topic.

This outline of systemic planning (SP) for the support of 'green decision making' was initially written as a working paper to the members of the SUSTAIN research team and the members of SUSTAIN's advisory board. This final book is an extended and edited version of this working paper.

Needless to say, I hope that the book – with its aspiration to provide a systemic planning (SP) approach that can be used to facilitate comprehensive and green decision making – will inspire some readers to test the approach and also to go more into depth with its 2012-forerunner *Complex Strategic Choices – Applying Systemic Planning for Strategic Decision Making*. More information about this book and SP is available at:

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http://www.systemicplanning.dk

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1. Planning out of the box

Planning before and today

Green Decision Making sets focus upon providing deliberate and method-based decision support for making *informed sustainable transport infrastructure decisions*. Such decisions can benefit from planning and make us see it as necessary when we confront this type of strategic decision making. However, the complexity of pursuing sustainability can also entail that the planning activity in itself becomes complex and thereby principally impossible. Thus, as a kind of paradox, planning with a focus on complex problems can be perceived as both necessary and impossible. However, the message of the book is that a systemic approach is worthwhile. Set out and described as systemic planning (SP) it can contribute to promoting green, i.e. sustainability-oriented decisions.

Planning can be seen as a highly integrated part of modern life which continuously with one of today's terms calls for innovation. Development and innovation depend in different ways on us being able to predict future courses of action when we plan and act in certain ways. Just as we more or less unconsciously plan a flight, so we also carry out planning in many other aspects, maybe even without really realising that we are actually planning.

However, planning as an activity is also subject to deliberate considerations. That is the kind of planning which is in focus in this book. In this connection it should be noticed that research into planning has typically been performed by economists and engineers when economic and technological knowledge has been called upon in different ways. Modern airlines thus need demand forecasts for the various destinations, and new types of airplanes are continuously planned based on e.g. possible alternative design choices relating to fuel efficiency, passenger comfort, etc.

Planning has become synonymous with active handling of the future and its challenges. Apart from this general scope, planning occurs in many concrete circumstances which of course in each particular case contributes to a more detailed description of what planning consists of in that particular circumstance. Just to mention a few examples, we have public budget planning, hospital planning, urban planning and transport planning, and in the private sector we have business planning, resource planning etc. We have planning at the EU level and planning at the national governmental level as well as at the municipal level. And of course it also makes good sense for busy families and individuals to talk about planning so that they can combine their professional and private life, and when they prepare their holidays. In several of these cases planning can – fortunately – take place unconsciously, but it is typical for planning as described in this book that *planning is considered as a deliberate activity which can be reflected upon.*

Today planning is a totally integrated part of modern society, and its inherent idea of coordination and rationalisation is reflected in theories and methods such as for instance New Public Management (NPM) in public administration and Enterprise Resource Planning (ERP) in private enterprises. Modern versions of planning have, among other things, been furthered by a revolutionary IT development which via the Internet has allowed the formation and dissemination of network communities whose possibilities and consequences we are far from understanding even partly. But if you schematically frame "planning before" as the period from the 1960s till the millennium, "planning today" considered as the post-

millennial period is characterised by completely different societal conditions. In the 1960s, a prolonged stable period of rapid economic expansion gave rise to the concept of long-term planning, among other things because it made good sense to prolong growth curves which in different ways were a result of increased prosperity 'up and to the right'. Here the number of cars in Denmark can serve as an example. Today the concept of long-term planning is hardly one of the common concepts in the more hyped consultancy language. Now we talk about "road maps" and "strategizing" etc., which in this connection must be interpreted as varieties of planning which illustrate an unchanged need for being able to look ahead (also somewhat longer than the budget years). Nonetheless, planning has kept its generic meaning with respect to coordinating and rationalising, but the framework conditions have changed substantially, especially when we go beyond the short perspective and take the longer view.

A very interesting development can be observed with respect to the planning-theoretical approach where emphasis in the 1960s and 1970s was on the 'right process' (in academic journals often referred to as "theories of planning"), whereas in the 1980s and 1990s emphasis was put on the concrete understanding of planning with respect to the 'right substance' (in academic journals referred to as "theories in planning"). There is hardly any one-label planning theoretical 'school' of today. In this presentation it is the intention to discuss and consider whether *the conditions are so new and different that the generic meaning should be examined from a new angle*. These will comprise both process and substance which will both be seen as being conditioned by a decisively new societal condition, i.e. the ever increasing complexity, among other things furthered by the network community.

The way to approach this is to study what we would normally refer to as *an existing complex planning problem*. In this case the planners have by means of analyses etc. reached a number of 'solutions' in the form of various strategic options, each of which has a series of consequences. We can consider these as *a set of future-oriented choices*.

The suggestions and ideas described below mainly come from issues relating to the choice between alternative large investments in transport infrastructure, but the description is made so general that the reader can see that it can also be used within other fields. A major case is about strategic relocation – a complex planning challenge which can be found in many public and private enterprises. In this case, the set of future-oriented choices are the possible new locations, including all their possible consequences.

Focus on the set of strategic future-oriented choices

If not otherwise stated planning is therefore in the following presentation associated with establishing a basis for making strategic choices. With this strategic delimitation, we identify a type of planning problems which may have quite significant consequences in many organisations and companies, i.e. they cost dearly in different ways if the planning turns out to be erroneous. Planning in connection with strategic choices is also often of a more long-term character, including for instance coordination of activities and costs which are continuously undergoing changes. But in the longer run, the uncertainty increases. The uncertainty for its part depends on the surroundings in the broadest sense of the word. If not specified further the planning task below is seen as carried out by *a team in an organisation or company of a certain size where the organisation or company in question must take into consideration different strategic choices of decisive importance*. In brief, the strategic option is linked to the further development of the system. As to the distribution of roles, the planning team is responsible for establishing a planning basis which the responsible management can use to make strategic choices. In the following we will refer to this as *a decision support task*.

As mentioned above, the planning task can be set out both in a general and a more concrete way and both are important. We will consider the general consideration as the way in which the planning team approaches the task, i.e. how are the possibilities to define the most reasonable strategic choice by means of planning perceived? Which applicable

principles and methods are available? Naturally, such a general consideration is closely linked to more specific questions: Do we know enough? Which previous experiences do we have? Is the surrounding world, both in a broader and narrower sense, behaving in a more or less predictable way?

The purpose of this book is to consider the possible role of planning in case of complex planning problems as they come forward when dealing with various kinds of strategic choices. Put in a schematic way, you could say that "planning now" in the new millennium with its growing globalisation, including the interweaving of local issues with national and international issues, accentuates a new type of planning challenge. The novelty lies in the difference between "complicated" and "complex".

The difference between complicated and complex

As described below, since its establishment in the 1960s and during the 50 years that have passed since then, planning has developed and widened its scope. Organisations and companies have developed, and the surrounding world has evolved meaning that, in many cases, the planning task has gone from being complicated to being complex. But what is the difference between a complicated and a complex planning task?

We normally associate complexity with something which cannot be completely determined and decided. The concept has its origin in the Latin "complexus" which means that something is "interweaved". We therefore talk about complexity if many components or elements are merged in an unclear way. At first sight, it is not possible to define complexity precisely, but it can be tracked down using a form of negation, i.e. *we talk about complexity when we cannot get an overview of or determine a phenomenon by means of the procedures, concepts, theories, methodologies etc. which we would normally use.* In this way, complexity becomes something not understood or something not yet examined in detail.

Generally, people agree that a modern car is complicated and that repairs should be done by a mechanic who typically uses diagnostic

equipment and special tools. When the car has been repaired and leaves the garage and the driver, maybe during rush hours, enters a heavily congested road network, it may under given circumstances be more natural to describe the traffic flow in which the car moves around as complex. This is due to the fact that we may well be able to forecast quite a lot about the expected traffic operation in the form of speed, delays etc., but the decisive thing is, however, that the car from one moment to the next is subject to conditions which can vary in a way which in principle makes the operation unpredictable and uncertain. The car ahead can break down so that suddenly there is only one lane available etc. All events are mixed up in a pattern as the many road users respond in different ways. The overall result is that the driving situation in for instance dense urban traffic must be considered as complex as compared to the complicated repair.

Above the theme of the book was presented with focus on strategic and complex future-oriented choices. Generally, strategic future-oriented choices can be both complicated and complex. Put in a schematic way you can categorise problem-solving situations as shown in Table 1.1, where a total of four situations A, B, C and D have been established according to how goals and means (described as procedures) can be characterised as either "certain" or "uncertain".

Table 1.1 Different problem-solving situations.

Problem-solving	Four problem-solving situations with different combinations of "certain" and "uncertain" goals and means	
MEANS: *GOALS:*	Determined and known procedure	Exploratory and not known procedure
Certain goals	A: Calculation with known procedure	C: Compromise
Uncertain goals	B: Assessment	D: "Chaos or inspiration"

In situation A we have both certain goals and means. The problem-solving will be based on a known procedure. A trip from one place to

another where the choice is between train and plane can be found via the Internet. If the goal is either the cheapest price or the fastest trip, you can make a best possible choice. If we become unsure about the goals - it should be relatively cheap, but also relatively fast - we have a B-situation where we must base the choice on a more detailed assessment: How important is the price? How important is the travel time? Yet another type of uncertainty occurs in situation C, because what happens if we are several people travelling together and driving by car is also an option? And would it be an advantage to combine the travel modes? With the D-situation we have the most uncertain problem-solving situation as we could for instance imagine that we must also take into consideration a possibility for sightseeing. In this example various decision-making situations are illustrated in which the solutions, in principle, range from being based on a calculation algorithm in situations A via B and C-situations with use of operations research (OR) methods including optimisation mathematics and multi-criteria analyses to finally the undefined and open situation D. With focus on a strategic choice in connection with a set of future-oriented choices, the grades of uncertainty will interfer, so here we find ourselves in the B and C situations. In case of high degrees of uncertainty, the situation will move towards D. A crucial point, which is illustrated above, is that from solution situation A to solution situation D we go from types of solutions which can be described as *more or less complicated to more or less complex.* The idea of using systemic planning is based on the fact that complex planning problems should be handled in a different way than complicated planning problems. Taken to the extremes we can say that the complex planning problem as compared to the complicated planning problem requires out of the box thinking!

Systemic planning as an idea

The word "systemic" indicates that an interaction takes place between factors within a whole in which it is not possible to map this interaction precisely with respect to what causes what and with which effect. As an

example can be mentioned the "systemic banks" from the financial crisis experienced in later years. On this background does systemic planning then make sense?

A first step to explain what it consists in could be to refer to more conventional planning as systematic planning. Systematic emphasizes a known procedure with sub-results which in a well-known interaction lead to a planning result. The systematic planning process can be very sophisticated with theoretic planning algorithms which for instance determine the optimum route in a complicated network or the best possible staffing schedules for complicated production processes. Would it then not be possible to imagine that if the actual planning problem – if it is further complicated – could be solved by refining the systematic planning accordingly? It seems reasonable and is done in many cases with good results. However, sometimes you find yourself in a situation where you 'hit the wall' due to the difference between the complicated and the complex. This can be illustrated by means of some dimensions that demonstrate different types of complexity. These dimensions are described below and named detail complexity, dynamic complexity and preference complexity, respectively.

Detail complexity

The general definition of a system is that it consists of a whole that comprises a number of interacting elements. The system is delimited from a surrounding environment. Such a system can be used to set up a mathematical model which reflects the way in which the acting elements influence each other. When such a set-up model can be used to imitate or reproduce the underlying system in a satisfactory way, the model can be used to determine what will happen in the system when an intervention is made. For traffic models it could be to determine the size of new traffic flows if you for instance change the land use by developing an area and/or by constructing new transport lines. The questions used in the model in connection with the modelled system are often called what-if questions.

An important concept regarding this type of activities is the validity of the model, i.e. whether the results of the model are 'good enough' with respect to the real world as reflected in the model. Again, such an answer depends on what the model is to be used for or more precisely what is required with respect to precision. In transport planning an important field is precisely traffic models which over the years have become very mathematically advanced. Nevertheless, it can be maintained that the result still is that the more detailed predictions you want to make based on these increasingly comprehensive models, model validity will remain a very big challenge.

In summary, what-if questions which are based on increasingly complicated modelling principles based on an increasingly complicated model design, including the use of increasingly growing data volumes and different kinds of data types, are moving towards the wall that separates the complicated from the complex.

Dynamic complexity

The use of future-oriented what-if questions complicates the system description and the related modelling as the elements acting in the system are not static, but change over time. In this way the patterns of influence are also changed and it may have vital importance for the overall system development. An often used example to describe this stems from the meteorology where it is vividly described with reference to "The Butterfly Effect", i.e. the flap of a butterfly's wing in Brazil sets off a tornado on the other side of the planet three days later. In the mathematical jargon it means that a tiny change in the baseline conditions of a complex forecast model can be of vital importance for the result of a model run that provides a model forecast for a future situation.

Preference complexity

Both detail complexity and dynamic complexity are well-known concepts for model builders with an OR education. The importance of normative

preferences in the form of parameter specification and value trade-offs which are embedded into and/or paid attention to in various ways when setting up the model is also well-known. In most cases this part of the modelling work is taken into account by consulting the steering group of the model development project or by using laid-down standards. In the field of traffic such standards have arisen through unit prices laid down by the Ministry of Transport that state the value of for instance a saved travel hour or a saved traffic accident. When cost-benefit analyses, which are described in detail later, are performed and these unit prices are used, then the assessments behind the unit prices are reflected in the result of the cost-benefit analysis and thereby also in the go or no-go recommendation as regards an examined alternative in the set of future-oriented choices.

The reason why we talk about preference complexity here is that complex planning problems, in a different way than complicated planning problems, require considerations as to how the preferences are included in the planning in the best possible way. A challenge in this respect, based on findings within systems theory is that *preferences are to a large extent created by and tested in communicative processes*. This is very much related to the German sociologist Jürgen Habermas and his *Theorie des Kommunikativen Handelns* from 1981. We will later illustrate this by showing how systemic planning can promote creative and sustainable decisions where the preferences of various stakeholders are formed and interact as the basis of the assessments of complex future-oriented choices.

Systemic planning as out of the box planning

The ambition of systemic planning is to take over when systematic planning becomes insufficient. As described above the solution of an increasingly more complicated planning problem is not gradually transformed into the solution of a complex planning problem by increasingly refining the systematic methods. Creative and sustainable decisions in relation to complex future-oriented choices require out of the box thinking – or even better – out of the box planning when different

types of 'complexity walls' form a box that delimits the systematic and analytical procedure. Outside the box many new challenges and uncertainties have to be confronted by the planner. The book suggests how to approach such challenges. Thus it provides a more detailed description of the systemic approach in Chapter 2, a range of different examples of application in Chapter 3 and finally a more coherent assessment in the concluding Chapter 4 that discusses and assesses whether systemic planning with its processes and methods can actually lead to better decisions in situations where complex choices are to be made. Two appendices give more technical information on learning and modelling issues.

2. The systemic approach

Systemic planning and its use of five perspectives

SP as wider holistic learning

As already briefly mentioned systemic planning (SP) aims to take over when systematic planning, at best, becomes insufficient, or what is even worse maybe directly misleading. Basically SP is about *wider holistic learning* through a combining of different, explorative perspectives ('epistemic lenses'). SP is not an alternative to systematic planning which it seeks to incorporate in a more comprehensive planning approach, but a practice-oriented way of applying both rational and arational (non-rational, intuitive) thinking for planning and decision support. If usual rational thinking linked to *analytical decomposition* expresses features of intelligent simplification thinking, we can see arationality as expressing a kind of *synthetic composing*. Or in more everyday language: as a kind of intelligent, holistic behaviour. With the SP approach we seek to benefit from this type of behaviour when dealing with a complex planning problem by making use of five specific explorative perspectives. The identification of these five perspectives is informed by the way that systems thinking as applied within management engineering has

developed over the years. This is described in Appendix I and in more detail in *Complex Strategic Choices*.

The five SP perspectives

SP uses five different perspectives to deal with the complex planning problem. The perspectives are listed below:

1.   Core Performance (CP)

2.   Wider Performance (WP)

3.   Fairness (FA)

4.   Diversity (DI)

5.   Robustness (RO)

The idea behind the five perspectives is to provide a more comprehensive approach than each of these would be capable of delivering alone such as for instance the Core Performance (CP) perspective. The role in SP of each of the listed perspectives is outlined below. A description of their foundation as rooted in systems science is given with some details in Appendix 1.

Core Performance (CP)

With CP focus is put on one or several key effects of a given future-oriented choice where these weighted together are set up against the costs involved in the future-oriented choice in question. The conventional method used here is the cost-benefit analysis (CBA) where costs and benefits measured in adequate monetary units, e.g. Danish kroner (DKK), by means of calculation lead to performance indicators such as the benefit-cost rate (BCR), the internal rate of return (IRR) and the net

present value (NPV). These indicators are used to assess the core performance attractivity of the future-oriented choices. The CBA can be carried out as more or less comprehensive depending on the effects included.

A main point to be recognised as regards the CBA is that it provides a reasonable economic interpretation of the various effects, for instance how much a saved travel hour is worth in DKK. Or a saved traffic accident. Within traffic planning many countries have made significant research efforts to work out manuals for such socio-economic cost-benefit calculations. In Denmark we have a manual from the Danish Ministry of Transport from 2003 which has been revised and republished in 2015. The manuals from the various countries have many similarities, but also differences which can give rise to different results depending on the manual used.

There is no doubt that the CBA has a well-established central position as an assessment method. It is also worthwhile noticing that CBA, despite this position, in many cases is not able to provide conclusive answers. The latter becomes particularly obvious if the assessment task to be performed regards a complex planning task.

In systemic planning the CP perspective is covered by means of CBA calculations which can be relatively simple, but also more comprehensive depending on the task at hand.

Wider performance (WP)

With the WP perspective the assessment is extended to also comprise effects that are important in a wider context. In this connection, in traffic planning you often talk about so-called strategic effects which cannot directly be subject to a monetary interpretation, but will, however, be important for the future-oriented choice. The type of method that can be used in relation to this perspective is a multi-criteria analysis (MCA).

In systemic planning the WP perspective is covered by means of two fundamentally different types of analyses. In the first analysis which is performed using the COSIMA method (composite model for assessment)

the assessed relative importance of the economic and non-economic effects are used in an interactive process. In the second analysis which is performed by means of the SIMDEC method (<u>si</u>mulation and <u>m</u>ulti-criteria analysis for <u>dec</u>ision making) a series of assessment factors are treated, including among others a simulation-based benefit-cost rate, by means of a pairwise assessment procedure that leads to an overall relative assessment of the attractivity of the various alternatives.

A more detailed description of CBA, COSIMA and SIMDEC and the methods mentioned below is provided together with the presentation of the examples in Chapter 3. The aim of this chapter is solely to introduce the possibilities of the methods as elements of a systemic planning process.

Fairness (FA)

With the FA perspective focus is put on the stakeholders involved in the planning task in question and on shedding light on the conflicts that may be present in case a common decision is to be made. The methods to be used here are scenario analysis and preference analysis, possibly in combination with the CBA and MCA methods described above. Examples of these applications are provided in Chapter 3. Generally, these methods belong to the category of methods which in operations research (OR) are named "hard methods". Methods from the OR category of "soft methods" are, however, also important for the FA perspective. These methods comprise brainstorming, mind mapping, SWOT analysis etc.

Diversity (DI)

The DI perspective tests if some relevant factors or approaches to the complex planning problem at hand have been completely ignored and that no unintentional omissions have been made in connection with the problem description of the complex planning problem. In the group process which is described at the end of the present chapter, it is a recurring theme that recognised new important issues should lead to a reassessment of earlier steps of the process. Here the mentioned soft

methods play an important role; in OR these methods are therefore also sometimes called the structuring methods. We once again refer to the examples in Chapter 3.

Robustness (RO)

The RO perspective plays an important role in case of a complex planning task as uncertainty and complexity can influence the outcome in different ways. The previously described three types of complexity are important here. Relevant methods here are sensitivity analysis, Monte Carlo simulation and the SIMRISK method (simulation-based risk assessment). As described in Chapter 4 the latter will allow the decision-makers to judge for instance the realism of the estimated construction costs of the actual project as well as the realism of the established foundation of the forecast.

A combination of soft and hard methods

Based on the five SP perspectives introduced above you can, expressed in a schematic way, say that a conventional but complicated planning task can be solved by means of a CP perspective which is reported with supplementary descriptions, including circumstances not covered by the CBA calculations.

Against this approach you can have a complex planning task which cannot be handled by means of a distinctly systematic planning procedure as was the case of the conventional, but complicated planning task. In case of a complex planning task it can be asserted that SP – characterised by an interaction of the five described perspectives – can lead to planning solutions and decisions which in a more comprehensive way than systematic planning can assess the possible strengths and weaknesses of each of the options in the set of future-oriented choices.

The interaction between the five perspectives takes place by a combination of hard and soft OR methods and by embedding this use in a group process, in the following referred to as a decision conference. The

basis hereof consists of the 2 x 7 methods shown in Table 2.1. The methods have been chosen based on their individual ability to contribute to the systemic process. The reason why there is a total of seven hard and seven soft methods is due to the wish of having a convenient number of different methods available as each of these imposes different demands with respect to immediate applicability and level of detail. In the cases presented later the methods are described in more detail based on how they are used in the individual case. Focus here has been to introduce the potential that the application of the individual method or technique may have in an ongoing SP group process. In a combination dependent on the actual planning task they serve the exploration of the five SP perspectives.

Table 2.1 Seven hard and seven soft system techniques and methods

Chosen methods to be used for method combination in a systemic planning process	
Hard methods	Soft methods
Cost-benefit analysis (CBA)	Brainstorming (BS)
Analytic Hierarchy Process (AHP)	Mind mapping (MM)
Simple Multi-Attribute Rating Technique (SMART)	Strengths, Weaknesses, Opportunities and Threats (SWOT)
Composite MCA models (COSIMA, SIMDEC)	Critical Systems Heuristics (CSH)
Scenario analysis (SA)	Soft Systems Methodology (SSM)
Preference analysis (PA)	Stakeholder analysis (STA)
Sensitivity analysis, Monte Carlo-simulation (RA), SIMRISK	Futures workshop (FW)

If a more thorough introduction to the individual methods, including the mathematical basis of the hard methods, is needed, reference can be made to either the descriptions of these in *Complex Strategic Choices* or to the website www.systemicplanning.dk

It is not possible to state exactly how many methods in combination that should be used in connection with an actual SP planning task. However, two or perhaps three soft methods will normally be sufficient to formulate and structure an SP course while two or maybe three hard methods will probably be sufficient. In the concrete applications of SP, deviations from this rule of thumb can, however, be seen.

Decisions as a group process

The designation "decision conference" literally sets the stage for the decision or decision recommendation to be taken at the end of this process. However, the decision conference should be considered in a wider sense as a form of planning workshop where a group process is created which has some inherent qualities when a complex planning task is to be approached. In principle, this is done by uniting three important elements, i.e. *decision analysis, group processes and information technology*, see Figure 2.1.
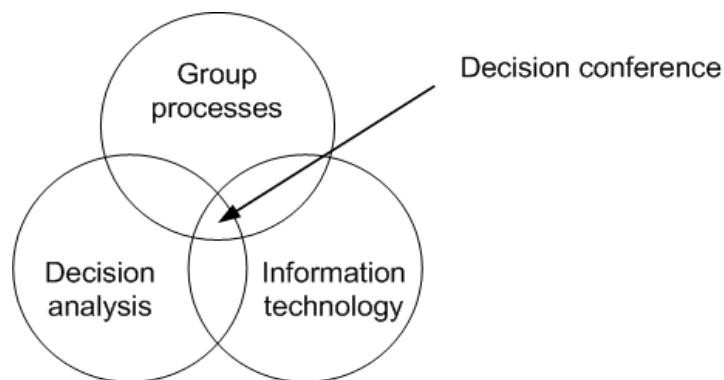
Figure 2.1 The decision conference as an interplay of decision analysis, group processes and information technology

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A decision conference can generally be seen as an approach that enables a group of stakeholders and decision-makers representing widely different views on for instance a company's goals and strategies to work together in a structured and efficient way with the purpose of establishing the basis for a visionary decision.

More formally you can consider the decision conference as a design in which a creative and structured self-organised seek-learn process can take place. In addition to final decision support the decision conference can also be worthwhile simply by unfolding the complex planning problem. Important sub-results here are for instance a clarification of which alternatives should be included in the set of future-oriented choices, which stakeholders should be involved, etc.

More schematically, a decision conference is characterised by the following:

- It consists of a half- or a one-day meeting (the time may vary according to needs)
- It aims to analyse important issues
- It involves key people who represent different interests as regards the outcome
- It is facilitated by an impartial specialist in group processes and decision analysis (facilitator)
- It uses a supporting decision model served by a decision analyst, helping to give the process structure

In practice, participants in the decision conference are placed around a table with the fundamental aim to receive information, discuss the problem and give feedback to influence the upcoming activities. As already mentioned a facilitator guides the process, among other things by the use of interactive decision-support information technology that models and displays the feedback given to the facilitator's various questions. The situation is shown in Figure 2.2.

The plants shown next to the smart boards (which are used in combination with information technology and decision analysis software) underline symbolically that it is actually very beneficial if the physical

Figure 2.2 An illustration of the physical environment of a decision conference

environment of the conference is good. If the budget allows it, the conference should be held outside the organisation or company.

The fundamental goal of using a decision conference as part of the SP approach is to create a synthesis from the dynamic and creative deliberations of the group processes and the applied decision analysis techniques. This synthesis can then contribute to creating a common understanding or clarify any conflicts that should be taken into consideration. Ideally, through their participation in the decision conference the participants get an impression of the common goal and commit themselves to act with a view to implementing the decision.

It is important for the quality of the decision conference that the facilitator opens the meeting by explaining the underlying theory of the decision model to the participants. In this way the participants will probably be more prone to accepting the subsequent model decisions based on different assessments when they have an idea of the methodology behind. However, as the decision procedure is very intuitive the participants need not have a full knowledge about the many theories and techniques used, but only the basic knowledge presented as introduction.

A group-wise learning process is essential for the systemic approach. In principle, one person could as an analyst go through the five SP

perspectives at his/her desk, but the group process in the form of a decision conference adds a dynamism which the individual participant will often experience as a kind of 'accelerated learning'. As described in the following sections, the group process in relation to a complex planning problem is seen to contain an important potential for adding value to the decision support that is the product so to say of the efforts contributed by the members. However, as will be emphasised and described later certain characteristics need to be present in the process to lead to a satisfactory outcome. As will be stated later: better decisions will result when group members in their accelerated learning make full use of the model results in combination with their individual and diverse skills.

The SP wheel as a process driver

Complex planning problems constitute major challenges as they cannot be dealt with in a satisfactory way by using a *systematic* planning approach and it can be argued that it may even be counterproductive to redefine and redesign the complex problem at hand with such a solving strategy in mind. Instead a *systemic* approach should be adopted which respects the impossibility of 'fully mapping' at least the following three types of complexity:

1. Detail complexity
2. Dynamic complexity, and
3. Preference complexity

We will briefly interpret these as the impossibility I) to fully describe the problem, II) to fully foresee its development and III) to fully get an insight into the motivations involved. Too simplistic interpretations of each of these three aspects may well lead to an overall failure of well-intended aspirations from the 'problem-owners' of various types: decision-makers, planners and stakeholders more generally. Below it will be argued that better decisions when facing a complex planning problem may be

achieved by group processes that adopt a systemic approach. For this purpose the systemic approach as described in previous sections of this chapter will be condensed into an 'SP-wheel', see Figure 2.3.

Step 1: Form or modify vision

The SP process begins with forming one or more visions that relate to the dealing with the complex planning problem that is the background for planning and decision making efforts. As examples we can mention a vision about a sustainable development (SD-vision) and a vision based on more or less continuing business-as-usual (BAU-vision). These visions may be supplemented by other visions, see e.g. the company relocation example treated in Chapter 3 with visions about an Øresund Region with a monocentric development and – to complement it – a vision about a polycentric development of the region.

Step 2: Form or modify choice set

The set of future-oriented choices consists of the alternatives that represent reasonable candidates for a final choice. Typically the set will include both expensive and less expensive solutions. Furthermore the set should include candidates that are more or less in accordance with one or more of the visions set out in Step 1.

Step 3: Form or modify stakeholder set

The set of stakeholders should include representatives of interests affected by the outcome. These may with a public project be representatives of the political bodies involved (local, national and in Europe e.g. the EU commission). Environmental groups will often also be represented. For a private organisation, such as a company, stakeholders could consist of the management and the employees having different views on for instance the priorities of the company's development.

1. Form or modify vision
2. Form or modify choice set
3. Form or modify stakeholder set
4. Explore Core Performance (CP)
5. Explore Wider Performance (WP)
6. Explore Fairness (FA)
7. Explore Diversity (DI)
8. Explore Robustness (RO)
? Finalise or revise (9 or 1?)
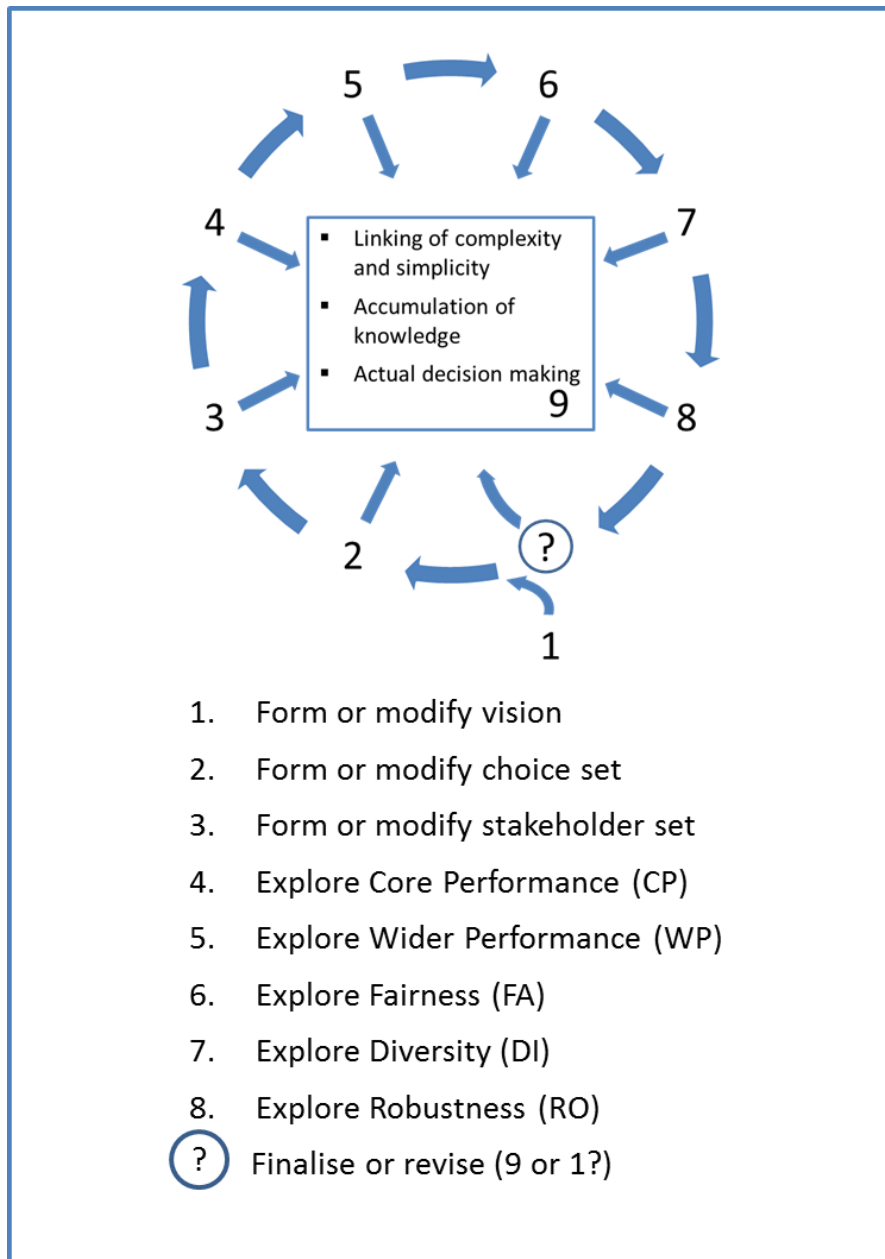
Figure 2.3 Overview of dealing with a complex planning problem by using SP and its five perspectives

Step 4: Explore Core Performance (CP)

With the CP perspective, focus is put on one or several key decision criteria or effects of a given future-oriented choice where these weighted together are set up against the costs involved in the future-oriented choice in question. The conventional method used here is the cost-benefit analysis (CBA) where costs and benefits are measured in monetary units.

Step 5: Explore Wider Performance (WP)

With the WP perspective, the assessment is extended to also comprise effects that are important in a wider context. In this connection, in traffic planning you often talk about so-called strategic effects which cannot directly be subject to a monetary interpretation, but will, however, be important for the future-oriented choice. The type of method that can be used in relation to this perspective is a multi-criteria analysis (MCA).

Step 6: Explore Fairness (FA)

With the FA perspective, focus is put on the stakeholders involved in the planning task in question and on shedding light on the conflicts that may be present in case a common decision is to be made. The methods to be used here are scenario analysis and preference analysis, possibly in combination with the CBA and MCA methods.

Step 7: Explore Diversity (DI)

The DI perspective tests if some relevant aspects and approaches to the complex planning problem at hand have been completely ignored and that no unintentional omissions have been made in connection with the problem description of the complex planning problem. Here soft operation research methods play an important role.

Step 8: Explore Robustness (RO)

The RO perspective plays an important role in case of a complex planning task as uncertainty and complexity can influence the outcome in different ways. Relevant methods here are sensitivity analysis and Monte Carlo simulation. The latter can be applied as part of a reference-class forecasting examination, which essentially means to examine the project by using results about the known performance for a group of similar historical projects.

Step 9: Actual decision making

As reflected in Figure 2.3 showing the SP-wheel, the process is iterative. Due to the complexity no aspect is ever fully isolated, determined and 'solved'. Degrees of understanding are expected to come forward as a result of the group process described earlier. This will typically lead to later modifications of previous steps in the SP wheel. With the successive feeding of sub-results into Step 9, see Figure 2.3, knowledge and insights about the complex planning problem will accumulate towards a final recommendation. It should be underlined that the validity of the outcome is dependent on the quality of the insights gained; thus no complex planning problem has actually been 'solved' or 'optimised' – instead through a kind of search-learn process a sort of linkage between complexity and simplicity has been achieved, see Chapter 3 and Appendix I for details.

   It is important to observe that the SP-process can be carried out on two levels of realism. One level is that a team of planners so to say define and simulate the various steps all the way through to a recommendation, maybe presented as a report that can serve as decision support for the actual decision makers. Another level is that real participants are involved as representatives of visions, possible alternatives and the actual stakeholders. Both levels are of relevance and it has been found by working with the SP approach that actually the simulation level application of SP can pave the way for a later real application.

Towards more sustainable strategic choices

An aspiration about promoting more sustainable strategic choices will depend on many issues which influence the comprehensive assessment of the alternatives that are examined as relevant in a given planning context. Systemic planning (SP) as approach here is, needless to say, layered into issues about I) our present understanding of the complex planning problem and its relation to sustainable development (SD) and II) our governance systems and their interlinkages within and across nation states, regions and world wide, with the latter here to be represented by the United Nations (UN) and its many SD-oriented activities. We may more specifically ask the following two basic questions: I) Do we in a sufficient degree understand, even with the recently formulated UN sustainable development goals (SDGs), the SD-factors that ought to influence the visions and criteria in a specific planning study? And: II) Do we have the SD-indicators that are needed under the specific circumstances? No doubt the years to come will lead to still better knowledge and frameworks.

In this book's outline of Green Decision Making (GDM) 'greening' of decisions is laid down through applying *visions based on differently balanced views of economic, environmental and social considerations.* This balancing shall also be reflected in the choice set and the stakeholder set, see the first three steps in the SP-wheel Figure 2.3. The specific visions can be painted in a lighter or stronger green colour, where the latter vision can be based on an explicit and strong emphasis on certain planning goal criteria. To exemplify the possibility of 'differentiated GDM-thinking' Figure 2.4 shows three types of criteria that were used as relevant for assessing new transport infrastructure. Based on sets of selected criteria (see Chapter 3 and Appendix II for details) the planning process led forward to decision support for prioritising between a 'more green' SD-oriented alternative and another 'less green' alternative, the BAU-alternative, based on a vision of continuing business-as-usual (BAU).

Green decision making (GDM) based on the systemic planning (SP) approach is a bottom-up approach where a final strategic choice may well

Criteria		
1. Economic	**2. Environmental**	**3. Social**
1.1 Competetion on transport markets	2.1 Animal welfare	3.1 Cultural heritage
1.2 Contribution to EU´s core network	2.2 Ecosystems and biodiversity	3.2 Gender equality
1.3 Effect on tourism	2.3 Existing assets and resources	3.4 Mobility by public transport
1.4 Free movement of goods	2.4 Local air pollution and air quality	3.5 Security
1.5 Integration of European tranport market	2.5 Noise	3.6 Social inclusion
1.6 International ties and and coherence between countries	2.6 Oil dependence	3.7 Territorial cohesion
1.7 Location of companies and logistic centers	2.7 Renewable energy	3.8 Townscape
1.8 New technology	2.8 Safety	3.9 Transport network and accessibility
1.9 Regional development	2.9 The climate/global warming	3.10 Travel freedom
1.10 Property rights/land-use	2.10 Water quality and resources	
1.11 Labour market		

Figure 2.4 An example of a list of criteria divided into the subgroups economic, environmental and social impacts

come forward as being the better one when compared to the other examined alternatives. In this way GDM can be seen as complementing the top-down way of thinking behind decision making driven by indicator(s)` fulfilment as the decision support. The novelty of GDM as based on SP may well lie in the way the SD-thinking is forced to mix with other 'not-that-green' visions and enter the actual decision-maker prioritising.

The remaining text of the book sets focus upon the use of the SP principles and is based on selected cases from studies undertaken over the last decade. At varying places around the SP wheel shown in Figure 2.3 they exemplify the activities contained in the SP process with the overall

purpose to present the flexibility and potential of the approach. The examples comprise both private and public decision support, with the latter dominated by transport infrastructure decisions. However, the methodology and process as set out in this Chapter 2 may well apply to other application areas than transport, be they public or private.

In addition to 'greening' of decision making as a need simply stated to go beyond typically economic core performance, planning and provision of decision support to be 'systemic' will demand that the SP-wheel and all its activities have been duly considered but not that all in a specific case have necessarily been fully fledged. In the examples to follow emphasis is on illuminating different aspects (steps in the wheel) which were found of relevance in the particular study. Seen in combination, however, the examples should function to demonstrate the overall flexibility and potential of GDM.

3. Some examples

Systemic planning (SP): A concrete case

The purpose of the first example is to present a concrete case where the systemic principles are used in a strategic decision task. The case concerns the relocation in the Oresund Region of the international consulting company TRANS-IT Consult Danmark A/S. Due to various circumstances we are dealing with a complex decision or planning task. Some things 'push towards' the decision to move to a new location, not least the need for more space than what is immediately available at the present central location in Copenhagen, and other issues have also become relevant now that the company has started thinking about relocation. To introduce this case a company profile is given below with an indication of the company vision etc. for TRANS-IT Consult.

TRANS-IT Consult Denmark A/S was established in November 2006 as a subsidiary company of the international group TRANS-IT Consult Inc. TRANS-IT Consult in Denmark has around 200 employees and worldwide approximately 15,000 employees and is one of the world's leading consulting companies in GIS, transportation, IT, environment and industry. TRANS-IT Consult provides innovative consulting within transport IT, industry, environment and GIS both in the domestic markets and internationally. The focus of the Danish branch of TRANS-IT Consult

is the rapid development in the Oresund Region and the opportunities that this development can lead to for the transport industry. The consulting services are based on extensive knowledge and many years of experience in the industry and on extensive knowledge and global capabilities and experience. The vision of the company is to become the leading Scandinavian consultant while consolidating the present strong position as an international company that is rooted in Scandinavia with a highly recognised expertise in this field.

The decision to be taken is a complex planning task, since there are only few quantitative goal settings on which to base the decision, but a number of qualitative wishes and requirements to the right relocation decision, ranging from restructuring of offices into office landscapes on the basis of a just completed although minor reorganisation to including also the concern that the new location should radiate the right image. Among a number of other requirements are also that the economic consequences should be 'sound' which means that although relocation will open the door to many new opportunities, the economy is also important. Another thing that complicates the decision is that the staff emphasises that it must not be too difficult to get to work. A number of the factors which should be included are therefore not readily measurable.

The management decides to set up a group with representatives from both the management and the various departments and staff groups to prepare a basis for the final decision. A dynamic newly employed engineer who has eagerly participated in the discussion becomes member of this group and suggests, based on his study at DTU, to use systemic planning (SP). The proposal is prompted by the numerous factors and uncertainties. It is agreed to apply SP, also because the participants agree that factors other than the purely economic ones should be visible when the final decision is made. It is also recognised that there is a stated desire in the organisation to obtain wide support among the staff even though the management is aware that it makes the final decision about the new location of the company.

Application of systemic principles

At the first meeting of the "Move Group", as it has already been baptised, the members discuss how to get started. Actually the participants undertake a brainstorming and in the light of this also a stakeholder analysis. The result of these two soft methods is fundamentally that "the economy is important, but should not count too much" and that the basis for decision "should not only reflect the views of the management", and that staff "should also have its say". In this way a first consensus has been created stating that the decision should be based on both economic and non-economic issues and that these must be seen both from a management point of view and from the staff's point of view. Furthermore, it has been decided that the project will start with the results from a consultant's report based on the economy at different locations – this report was actually already ordered by the management before the Move Group was established. However, it has also been decided that the decision basis will be provided by means of a decision conference which is the main way in which the application of the systemic principles behind a sound joint decision can take place.

The work in the Move Group is therefore divided into three phases: I) Discussion of the consultant's report when it is available, II) Pinpointing of the decision factors which apart from the economy should influence the decision factors, and III) Implementation of the final decision conference.

Consultant's report and preparation of the decision conference

Based on TRANS-IT's wish to relocate the company in the Oresund Region, the consultant's report has identified a total of 8 alternative sites, namely four on the Danish side and four on the Swedish side of Oresund. The 8 alternatives are shown in Figure 3.1 and can briefly be characterised as follows: Tietgens Hus in central Copenhagen is an older and very prestigious building located in Copenhagen's commercial centre. On the other hand, Arne Jacobsens Allé in Ørestaden is a new high-tech building located in the new business district close to the motorway and the

Location alternatives

Denmark: Sweden:
D1: Tietgens Hus – Copenhagen   S1: Västre Hamnen – Malmö
D2: Arne Jacobsens Allé – Ørestaden   S2: Hyllie Centre Area – Malmö
D3: Torvevej – Vallensbæk   S3: Svågertorp – Malmö
D4: Ålholmparken – Hillerød   S4: Söder – Helsingborg

Figure 3.1 The eight alternatives for the relocation of TRANS-IT Consult
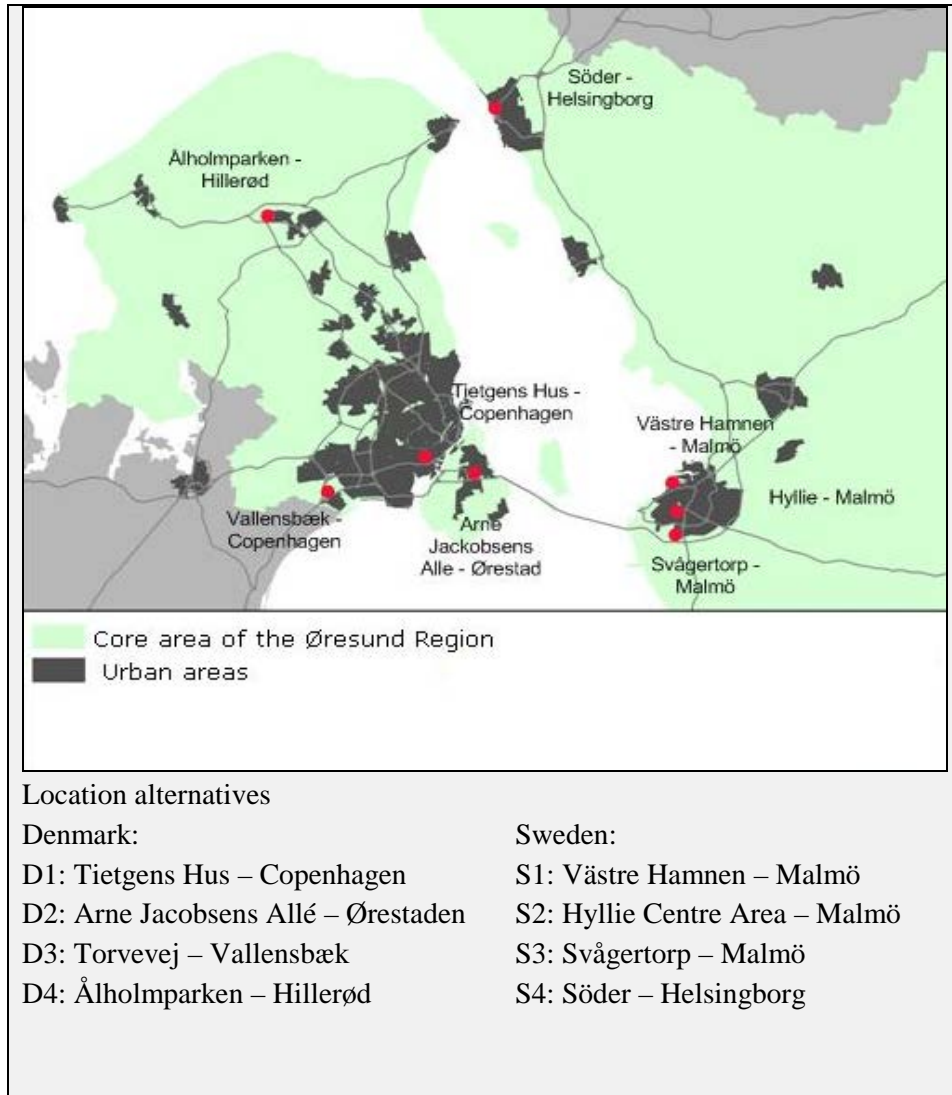
airport. Vallensbæk Torvevej is located outside the city centre in a cheaper and less prestigious area; however, there is a new office building with all modern facilities attached. An office building lying in the industrial district behind Ålholmparken in Hillerød makes up the north alternative, which is located outside the region's real centre, but which is

expected to have a strategic location depending on the developments in the region (in the following this location is referred to as Ålholmparken – Hillerød).

On the Swedish side of Oresund Västre Hamnen in Malmö equals the central location of Tietgens Hus in Copenhagen. Västre Hamnen is, however, a brand new high-tech office building, specifically designed to handle IT companies. Hyllie Centre Area is also a new high-tech building, but located in a new area in Malmö, which is ultimately planned to countermatch the Danish Ørestad. Svågertorp is in the more established industrial area in Malmö, which prestige-wise is comparable to the Danish Vallensbæk site. Söder in Helsingborg is the northern location site outside the region's centre; however, with the future development planned for this area it can get a strategic location.

The Move Group discusses the proposed alternatives and ends up concluding that the consultant has managed to screen the entire region very well with regard to possible locations. According to the task formulated for the management consultant, an overall requirement was that the new location of TRANS-IT Consult should be somewhere in the Oresund Region, but that within this constraint no possible location, which ought to be considered, should be left out. Next the Move Group addresses the economy calculations of cost-benefit type, which have been provided by the consultant. Based on data on rent levels, operating costs, removal costs, efficiency gains through redeployment and costs associated with breaking up (disruption costs) and differences between the Danish and Swedish wage levels, etc. B/C rates have been established which express the attractiveness of each location alternative from an economic viewpoint. These results are shown in Table 3.1 from which it appears that, in economic terms, a location in Helsingborg will be preferable. Since almost all rates are above 1, the B/C calculations also show that the very decision to move seems economically correct.

The B/C-rates give rise to an intense discussion of, among other things, what is currently included and what is yet to be taken into account and

Table 3.1 Overview of the B/C rates for the eight alternatives

Alternative	B/C rate
Tietgens Hus – Copenhagen	1.00
Arne Jacobsens Allé – Ørestad	0.80
Vallensbæk – Copenhagen	2.40
Ålholmparken – Hillerød	1.25
Västre Hamnen – Malmö	2.07
Hyllie – Malmö	3.05
Svågertorp – Malmö	2.83
Söder – Helsingborg	3.64

furthermore whether these matters may be included by 'calculation' or should only be addressed by 'wording'.

After the work programme has been agreed upon, the next phase concerns getting more clarity about other matters which in systemic planning is called the non-economic factors. In reality it is hard to separate economic and non-economic factors. One of the factors that has already, not least from the staff's side, been given much attention is the accessibility to the new location compared to the existing location, which is quite close to S-trains and subway at Nørreport Station.

This situation could well have been calculated in connection with the cost-benefit calculation. There are well-defined transport costs and an established practice of valuing the savings and costs related to changed travel time. There are also good ways of calculating the effect of making more or fewer shifts. Depending on the chosen alternative some home-work travelling may be substituted by car travelling, and also in this case it would be possible to calculate an economic difference between the before and after situation as it is called in cost-benefit analysis. Actually, using a geographic information system (GIS) and applying the knowledge of staff residences, fairly accurate calculations become possible.

The budget-responsible person of the Move Group, however, realises that a new extended cost-benefit analysis conducted by the consulting firm with inclusion of changed daily travel patterns of the employees will cost so much that there will be no budget means left for the planned decision conference. However, based on among other things a suggestion from the newly hired engineer that a less costly approach can be used when considering also the change in travel pattern, it is decided to stick to the work programme with the decision conference (DC).

The Move Group asks whether there are other methods in the systemic toolbox that could be used to gain insight into the non-economic factors to be included. It appears that in addition to brainstorming more demanding methods exist which can be used to pursue the issue. Among other things the engineer (now appointed DC organiser) mentions Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH). These methods are very suitable if you start from scratch. But the Move Group finds that this is actually not the situation anymore. During the three meetings the Move Group has had until now, it has discussed the matter so intensely that there is a feeling that both phase 1 and phase 2 of the work programme have been covered reasonably well so it is time to prepare for phase 3 with the decision conference.

The relocation decision conference

Based on the first two of altogether three work phases the Move Group members initiate the final decision conference. The conference begins with a summary of the findings from the previous phases 1 and 2 and an overview of the principles to underpin the conference, which, among other things, include that all arguments have the right to be heard and that this will be secured by the facilitator in an impartial way.

The facilitator then outlines how the conference is structured around a series of questions to be debated and how the group's deliberations concerning the answers to the individual questions will influence the progression of the work. After this introduction, where the consultant's

report and its conclusions have been presented, the facilitator asks the participants the first question:

Question 1. By applying CBA it was found that Söder – Helsingborg is the most attractive alternative. Do you agree?

If the participants agree with this outcome and feel that the CBA result is an appropriate solution to the problem, which would often be the case for more standardised assessment tasks, the decision conference may soon be over when everybody is satisfied with the CBA result. In case of non-standardised tasks, participants will, however, often disagree with the pure CBA-based choices and feel that the analysis is insufficient. This reflects the complexity of the issue and leads the facilitator to ask the second question:

Question 2. Is it possible to explain and put words on what is currently missing in the analysis? Can this be expressed by formulating some criteria?

This instigates a larger discussion during which it becomes relevant to draw on the views that were formulated already in phases 1 and 2. It is, however, important not just to adopt these but to reconsider them due to their importance for the further work.

The decision factors – in SP criteria or effects –which the participants want to include are defined below.

- Proximity to customers: The company's position in relation to its primary customers
- Image: The image the location and the building(s) present, especially to customers
- Size/flexibility: The size of the new environment (m^2/person) and the layout flexibility
- Facilities: The facilities associated with the site and the surrounding area

- Parking facilities: Parking facilities for cars, etc.
- Public accessibility: Its accessibility by public transport (bus, subway, train)
- Individual accessibility: The company's accessibility by individual transport (car etc.)
- Global accessibility: The company's accessibility in a global perspective in terms of proximity to airport

Normally, such a list cannot be set up right away but will 'materialise' out of a longer discussion. In this connection it is important to underline that at this point of time the individual criteria or effects are not prioritised in any way. Therefore the order as such is without importance. Together with the cost-benefit components it is now possible to set up a decision tree, see Figure 3.2.

When looking at the decision tree it is essential that no criteria are missing and that there is no overlapping between the criteria and that they can be regarded as additive to the cost-benefit calculation. In the further model calculations we talk about cost-benefit analysis (CBA) effects and multi-criteria analysis (MCA) effects. The further work in the group consists in assessing how each of the alternatives performs with respect to each individual criterion. This is called scoring of the MCA effects.

Characteristic here is that for each MCA criterion a value function (VF) is defined so that the best alternative with respect to a given criterion is assigned the value 100 and the worst criterion is assigned the value 0. The other criteria are then assigned scores between 100 and 0.

The technique made use of here is the Analytic Hierarchy Process (AHP). For each criterion the alternatives A and B are compared two at a time. This process is supported by the smart board screen, and the participants are asked if A is better than B, if they are equal, or whether B is better than A. If A for instance is better than B, it is marked on a scale whether A is "slightly better", "clearly better", "strongly better" or "very strongly better".
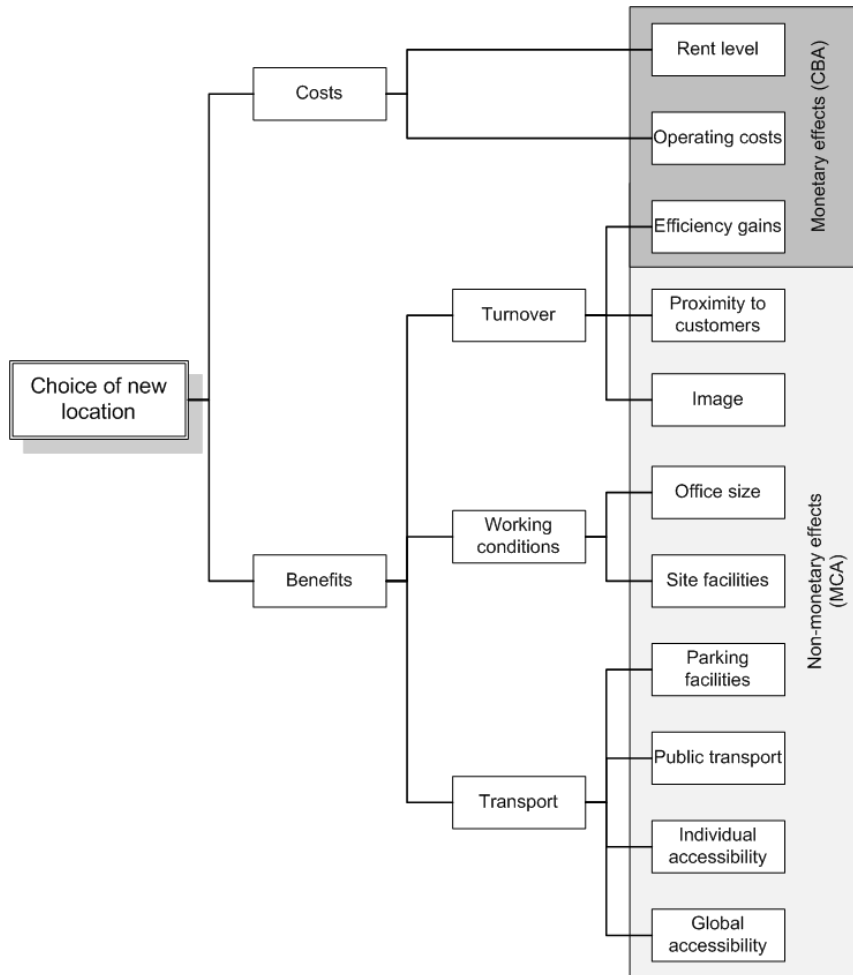
Figure 3.2 The formulated decision tree for the TRANS-IT Consult relocation case

Based on the AHP method and some related transformations VF scores for all eight location alternatives and all eight criteria can be established. It should be noted that when the number of alternatives and criteria increases, it is rather time-consuming to produce these scores. However, there are several techniques which can be used to reduce the number of pairwise comparisons so that this part will not take up too much time.

On the other hand there is no doubt that the group process is very important as the participants' awareness as to the qualities or attributes of the individual alternatives is increased. It should be mentioned that the analyst by means of different methods and techniques can supervise and support that a reasonable consistency in the overall weighting is obtained. In the literature on decision analysis there is general agreement that it is possible to obtain rather good, i.e. valid, scores which can be used in the further work. The result of this part will be an image on the smart board screen with VF scores indicated for all alternatives with respect to each criterion, see Figure 3.3.

No doubt this is an important step in the process and leads the facilitator to ask the third question:

Question 3. Do you think that the alternatives have been assigned satisfactory scores?

Typically some of the participants will consider some of the attribute scores as being "rather surprising", but after discussing the result, they are "not so surprising after all". At this point it is important to find out whether the participants agree on the assigned scores.

Until now the MCA effects have been equally important. That is hardly the case in real life and that is why the facilitator asks the fourth question:

Question 4. Is it possible to formulate and agree about an order of priority of the criteria according to their importance for the assessment?

The facilitator gives a brief background for the way the question is being asked. In fact the facilitator could ask the participants directly and jointly to assign weights to the individual criteria. However, experience shows that such a process is quite complicated for the group to perform.
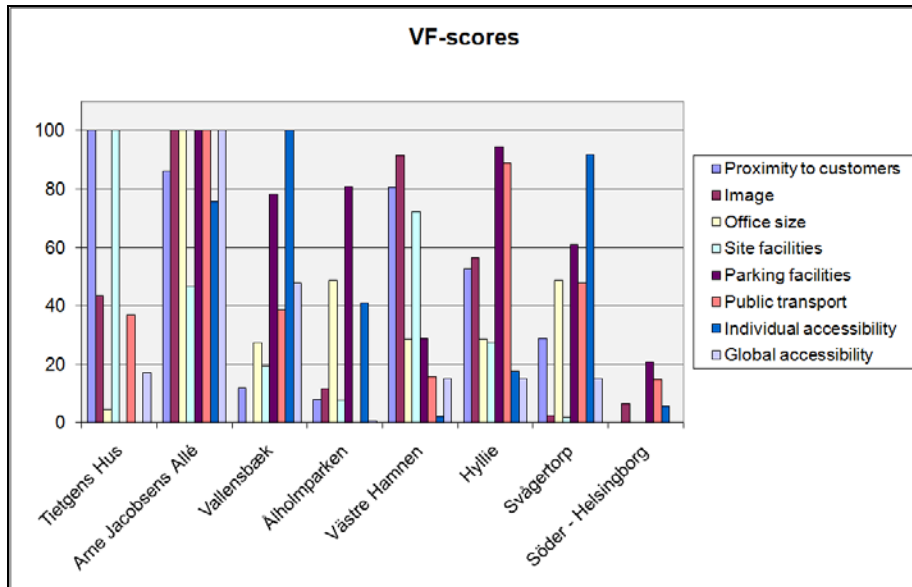
Figure 3.3 The scores for the eight alternatives assessed by eight MCA effects

Therefore we use an indirect technique which provides so-called Rank Order Distribution (ROD) weights that by mathematical principles and probability theory can provide a good estimate of the weights that lie behind a given ranking of the MCA effects. In this way the facilitator can focus on whether a joint prioritisation can be achieved.

The ranking of the non-monetary MCA effects may well vary depending on which employee level in the company that has to solve the task. Two strategies are relevant, namely a strategy made by the company's management and a strategy made by the staff. The below Table 3.2 shows the two different rankings with respect to the order of the criteria and their ROD weights.

The two rankings can be viewed as an expression of two different attitudes which the company wishes to use as the basis of the relocation decision. Thus the table shows that management will prioritise criteria such as image, proximity to customers and global accessibility. These

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Table 3.2 Two rankings and associated ROD weights

Priority	Management	Employees	ROD weight
1	Image	Individual accessibility	0.23
2	Proximity to customers	Public accessibility	0.20
3	Global accessibility	Facilities	0.16
4	Site facilities	Parking facilities	0.14
5	Individual accessibility	Size	0.11
6	Public transport	Image	0.08
7	Parking facilities	Global accessibility	0.05
8	Size	Proximity to customers	0.03

criteria are primarily concerned with the company's public face which is of course very important for the management. In this context it must be less important how the parking facilities are and how big the offices are.

The staff, however, wishes to attach great importance to individual and public transport accessibility and the facilities at the location. These criteria have a major influence on their daily working lives. Less important for the employees are global accessibility and proximity to customers.

The overall result for the MCA model is obtained by multiplying the VF scores from Figure 3.3 with the respective ROD weights from Table 3.2 and then add them to a total result for each alternative. The principles are described by the facilitator and shown on the smart board screen. In this way we obtain the results for each of the two strategies, see Figure 3.4.
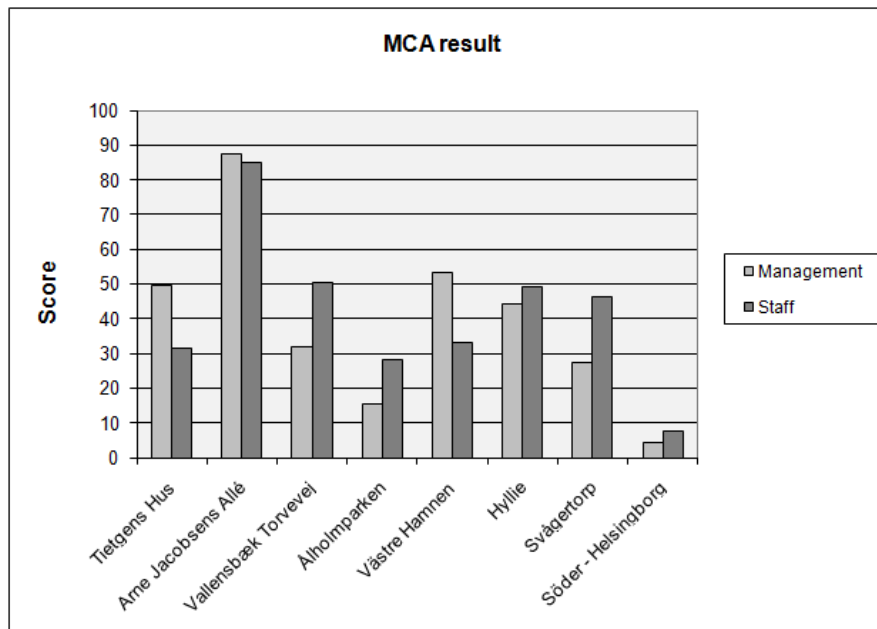
Figure 3.4 Results illustrated by two strategies: Management and staff

It appears that the attractiveness of the individual alternatives depends on which strategy (or 'policy') you choose to consider the problem. However, the two stakeholder groups agree that Arne Jacobsens Allé is the most attractive and Söder-Helsingborg, the least attractive alternative.

Were the final decision to be based solely on the non-economic factors and thus ignoring the consultant's report with the CBA results, the Move Group would be pretty close to having a foundation for a location decision. An interesting fact is, however, that the report (the CBA component) suggests a solution that is quite the opposite to the MCA component, as Arne Jacobsens Allé with respect to the calculated B/C rate, see Table 3.1, was the least attractive location choice and Söder-Helsingborg the most attractive.

The facilitator afterwards raises the following question and the analyst assists with some relevant screenshots to illustrate how to make use of both the CBA and MCA components at the same time. More technically it concerns how to weight the two parts together.

A basic principle here is that the results of the CBA part should not be changed, which means that the calculated B/C rates must be maintained. What is being changed is the MCA component which is indicated relatively with respect to the CBA, see Figure 3.5.
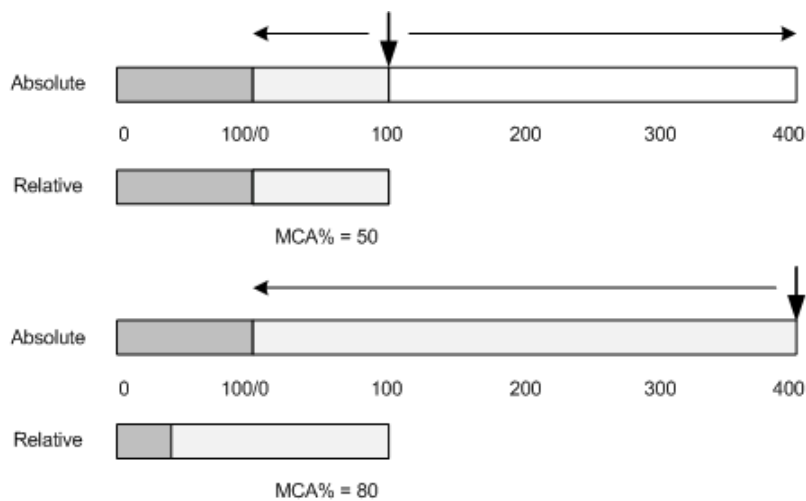
Figure 3.5 Chosen weighting of the CBA and MCA results expressed by the parameter MCA%

More technically, the principles are expressed by means of the COSIMA method. However, the weighting of the parts can be conceived also intuitively: the higher the MCA%, the higher the relative influence of the MCA component on the individual alternative's weighted CBA and MCA result.

On this basis the facilitator can ask the following question:

Question 5. How should the CBA and MCA be weighted expressed by an appropriate MCA%?

As the ranking of MCA effects could not be reached based on consensus about a single priority-order listing of criteria, it is conceivable that a single value cannot be focused on either. At some time the

participants will request to see the consequences of a variety of chosen MCA% values, which could then be the point of departure for further discussion. At the same time the participants would like to compare the results associated with the management strategy with the results of the staff strategy. Here it should be noted that experiences with the implementation of decision conferences seem to indicate that the use of several smart board screens is very convenient. In the present case thus a screen to display the results of the two strategies and ideally a screen that sums up important results and input at any time of the process.

First the results with respect to the management strategy are shown as a function of the MCA%, and *the total attractiveness of an alternative* is indicated in the form of the TRR value (total rate of return). TRR is an attractiveness rate that illustrates the value of the economic (monetary) and non-economic (non-monetary) effects in relation to the total cost invested in the relocation from the present location in central Copenhagen to the studied location alternative. From the first shown screen plot with all eight alternatives you can, when you have formed a general view of the situation, choose the most interesting alternatives after which the screen plot with the four shown alternatives in Figure 3.6 is obtained.
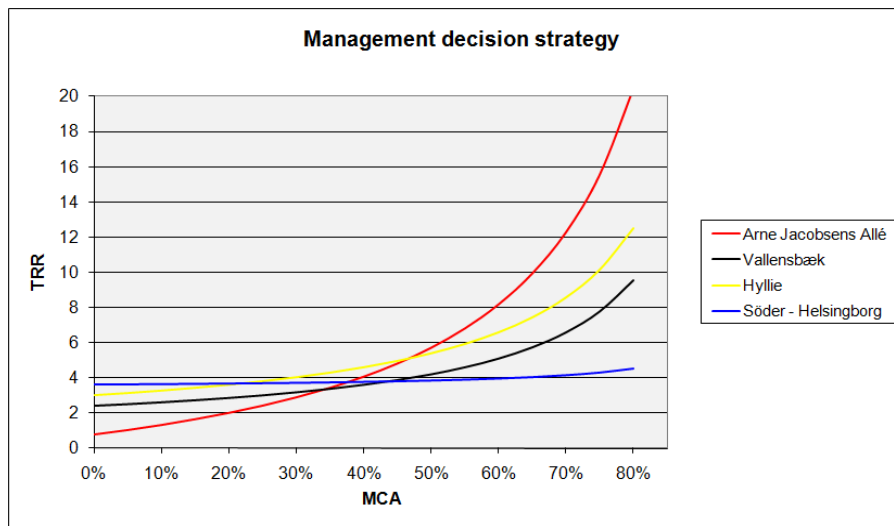

Figure 3.6 Management decision strategy for different MCA% values

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It can be seen that the attractiveness of the individual alternatives is very dependent on the actual MCA% used. In the interval from 0% and until around 25% MCA Söder in Helsingborg is the most attractive alternative which is in accordance with the result of the CBA. From around 25% and until around 45% the picture changes and Hyllie in Malmö becomes the most attractive alternative. However, in this interval something also happens with respect to the secondary locations where Arne Jacobsens Allé changes from being the least attractive alternative to becoming more attractive than both Helsingborg and Vallensbæk. Around 45% MCA the attractiveness of the locations changes and Arne Jacobsens Allé becomes the most attractive alternative for the rest of the interval.

This development is in agreement with the result of the MCA which is more or less opposite to the CBA results. The attractiveness of the alternatives with a high MCA score will of course increase significantly when more importance is assigned to MCA. Alternatives such as for instance Helsingborg, which has a very low MCA score, here only obtain a modest development in the total rate of return, TRR.

Similarly, the TRR values are calculated in accordance with the staff decision strategy, see Figure 3.7, again with four alternatives shown.
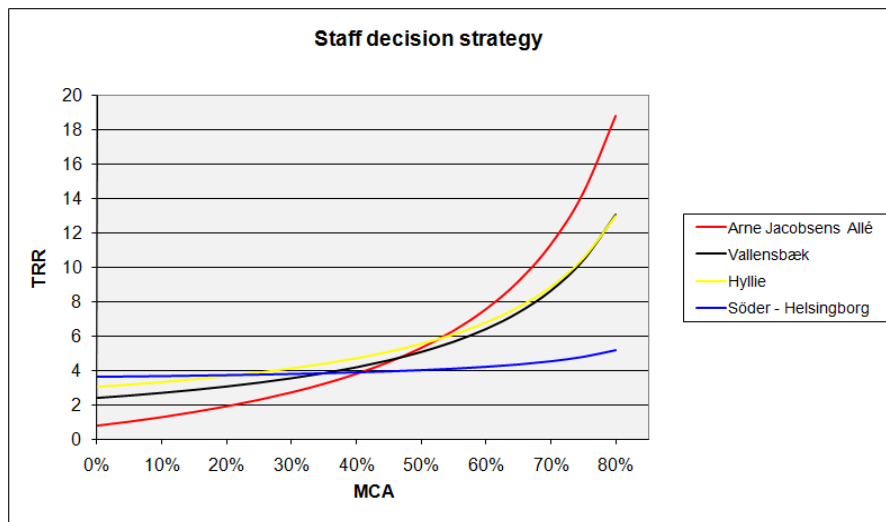

Figure 3.7 Staff decision strategy for different MCA% values

Figure 3.7 shows more or less the same tendencies as Figure 3.6; however, the intervals of attractiveness are slightly changed. Helsingborg is still the most attractive alternative between 0% and 25% MCA, whereas Hyllie is now the most attractive alternative between 25% and 55%; then again Arne Jacobsens Allé is the most attractive alternative for the remaining interval.

The differences in outcome as regards the management and the staff decision strategies are due to the different priorities of the MCA effects. In this case example the differences are, however, rather small, but in cases with bigger differences in the MCA scores due to the criteria rankings, bigger differences may occur when two different strategies are presented and compared.

The MCA% to be decided as recommendation for the final decision-making will depend on the type of decision problem being handled. In case of a major investment in for instance a large infrastructure project, CBA may dominate. Maybe the MCA can only be assigned 30% of the total analysis. For a decision problem as the one presented in the actual case, it may be more relevant to assign a bigger share of the total analysis to the MCA part, maybe even up to 70% of the total value of the analysis.

At this point, several things can happen in the process. There may be a sense of being 'close to' a basis for decision-making, but there may also be a wish to return to the input given to the earlier questions in the conference. An alternative's performance in the result graphs based on the sliding MCA can make one or more participants convinced that there is a criterion "we have completely forgotten", or that maybe with respect to a particular grading in a scoring "we definitely made a wrong choice as regards the intensity in that specific trade-off". It is of course important that such uncertainty and misunderstandings are cleared up. It may for instance be considered to include an additional criterion or decision strategy. This makes great demands on the facilitator who wants momentum in the process, but not at the expense of lack of consensus or dissatisfaction. For the further course of the TRANS-IT decision conference it is necessary that the participants at this point of the process

perceive that the results can "broadly be agreed upon". What remains is in terms of future uncertainty and robustness of choice.

On this basis, the facilitator formulates the following question:

Question 6. Until now a business-as-usual situation has been assumed. Are there other situations or scenarios as regards the future that ought to be considered?

In case of strategic decisions different scenarios can play an important role. The scenarios which the participants in the decision conference define and want to examine can contain components from both the company level and from the surroundings in the broadest sense of the word. The definition of scenarios can be underpinned by techniques from the futures workshop method which is listed in Table 2.1 together with the other methods and techniques used in the case description. In the present case the participants choose to focus on the importance of alternative developments (scenarios) in the Oresund Region.

The scenario analysis is based on three available scenarios that describe the present possible urban development tendencies in the Oresund Region: Baseline, i.e. unchanged (Base), Monocentric (Mono) and Polycentric (Poly). The three scenarios are presented in "Öresundsregionens infrastruktur og byudvikling for regionens udvikling frem mod 2045". As the case concerns a region that is still only partly integrated, the integration is expected to continue to evolve which is combined with different urban structure developments. The result of the analysis where the participants decided to proceed based on a model run with a MCA% of 40 is that the Mono development as compared to the Base development increases the attractiveness of Arne Jacobsens Allé. Thus this location now becomes the most attractive compared to Hyllie in Malmö, whereas the Poly development still points at Hyllie-Malmö as the most attractive alternative as compared to Base.

The work with scenarios automatically gives rise to considerations about other types of uncertainties which is materialised by the following question from the facilitator:

Question 7. Do you find it relevant to make a risk analysis of specific parameters or values?

An example of such an examination is that the CBA results are assessed with respect to the efficiency gains foreseen. What will happen if the anticipated efficiency gains are 'only' included in the form of various probabilities related to different types of efficiency gains and would that be critical? What happens if the Danish-Swedish wage gaps gradually fade away, also illustrated by the use of different probabilities?

The developed software is able to handle such considerations by means of Monte Carlo simulation which is also included in Table 2.1. The necessary parameters can here be set with various degrees of involvement of the decision conference participants. However, at this stage it is also a goal that all conference participants obtain a basic understanding of the decision-support calculations carried out. In the present case, the risk calculations show that if the MCA contribution is ignored, the uncertainty calculations could be used to sow doubt about a relocation to either Tietgens Hus or Arne Jacobsens Allé based on a purely economic analysis.

The recommendation of the Move Group

At this stage, there is a feeling in the Move Group of having established a basis for a decision about the new location of TRANS-IT Consult. The facilitator gives the following summary of the findings:

The results of the various parts of the analysis have identified three main alternatives, i.e. Söder in Helsingborg, Hyllie in Malmö and Arne Jacobsens Allé in Ørestaden. The cost-benefit analysis (CBA) gives the decision-makers a clear picture of Söder in Helsingborg as being the economically most attractive site for the company's new location. This is

in contrast to the result of the multi-criteria analysis (MCA) which points towards Arne Jacobsens Allé in Ørestaden as being the most attractive alternative. A combined CBA and MCA rating then determines that the overall attractiveness of the alternatives to a great extent depends on the weighting of the CBA and the MCA. At a low MCA% (below 25%) Söder in Helsingborg remains the most attractive alternative, but as the MCA% increases (25-45%) Hyllie in Malmö becomes the most attractive alternative and later again (above 45%) Arne Jacobsens Allé in Ørestaden stands out as the most attractive alternative. This tendency was seen for both the studied strategies, i.e. the management strategy and the staff strategy. The staff decision strategy 'only' moves the MCA% from 45 to 55%.

On this basis the conference participants recommend Arne Jacobsens Allé in Ørestaden as the first priority proposal and Hyllie in Malmö as its nearest competitor. The recommendation is supplemented with the comments and arguments made during the decision conference including also the scenario- and simulation-based robustness testing.

Summing up of the case

The described relocation case can serve to illustrate the opportunities that systemic planning (SP) can offer in complex planning tasks. In this connection focus has been on describing the main issue of a systemic process, i.e. *the interplay between decision analysis, group processes and information technology*.

An immediate assessment of SP can start by considering whether the Move Group when preparing a decision about relocation of TRANS-IT Consult has actually reached the right solution at the end of the decision conference?

The point is that you cannot know that for certain. But you do know that the Move Group by means of a supposedly rather intense process must have obtained quite good competencies with respect to the task at hand. An essential difference between a complicated planning task and a complex planning task consists in that the various kinds of calculations

made in SP mainly serve as basis for search-learn results and not as an overall one-way model result.

SP and creativity

In the above relocation case, COSIMA from Table 2.1 was used as a so-called hard method whereas brainstorming and stakeholder analysis were included as soft methods. In Table 2.1 COSIMA is stated as a "composite" MCA model meaning that the multi-criteria analysis (MCA) is composite, i.e. associated with the cost-benefit analysis (CBA). Methodologically you may say that the COSIMA technique ernables a more comprehensive analysis than what is possible with CBA. This is because several inputs from the group process are used when considering the questions and related judgments thereby providing a 'composite' answer to the question about the attractiveness of the individual alternative. Popularly speaking, you may say that COSIMA maintains the 'language' of the CBA and sets the scene for an overall assessment of all relevant factors built upon a CBA result. It should be stressed that in COSIMA the result of the CBA analysis as a benefit-cost rate is maintained (i.e. when MCA% = 0 as shown in Figures 3.6 and 3.7). COSIMA thus aims to provide an absolute value of the individual alternative built up by means of an unchanged CBA contribution with the addition of an MCA contribution based on the group deliberations.

SIMDEC is another possible composite model stated in Table 2.1, and the difference between COSIMA and SIMDEC, expressed in popular terms, is that CBA is not the starting point in SIMDEC, but is included as just one of several decision factors forming part of the overall decision. SIMDEC also leads to a quantitative indication of the attractiveness of the individual alternatives, but here the resulting value is only an expression to be used for a relative evaluation of the alternatives assessed.

Systemic planning (SP) is built upon the use of five perspectives where the first perspective, Core performance (CP), is supplemented by another four perspectives, the first of which is the Wider Performance (WP)

perspective. With the cost-benefit analysis as an expression of CP you can say that both COSIMA and SIMDEC aim to illustrate CP + WP. The main difference of COSIMA and SIMDEC consists as mentioned in the role assigned to the cost-benefit analysis. Whether COSIMA is preferable to SIMDEC or vice versa must be assessed based on the concrete decision task. Below SIMDEC will be illustrated by means of a case regarding a fixed link between Elsinore and Helsingborg. This case aims to demonstrate how to work with *creativity in the decision basis*, whereas the next case about the EU transport corridor from Helsinki to Warsaw will demonstrate how to work with *sustainability in the decision basis*.

New fixed link between Elsinore and Helsingborg

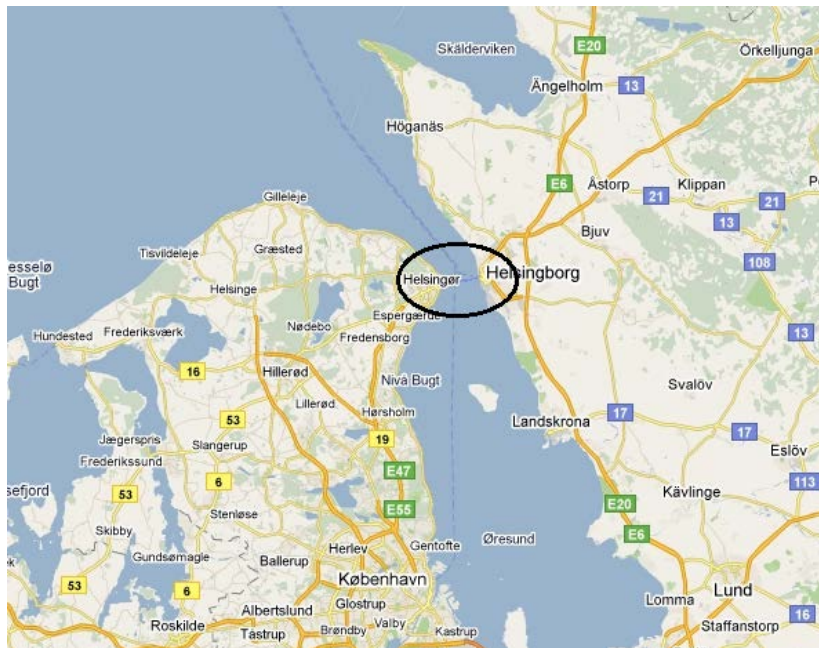In this example four infrastructure alternatives are considered within the area shown in Figure 3.7.

Figure 3.7 Location of new fixed link between Elsinore and Helsingborg (from Google Maps)

The alternatives are the result of many years of study. Here we are dealing with a complex planning problem because the four alternatives solve different transport tasks and because each of the alternatives influences not only the regional transport network, but also the international network, as the alternatives affect the interaction with the southern fixed link over Oresund from Copenhagen to Malmö in different ways. The alternatives are specified below:

Alternative A1 regarding a railway tunnel (2 tracks), only passenger trains, cost: 7,700 million DKK

Alternative A2 regarding a railway tunnel (one track), freight trains, cost: 5,500 million DKK

Alternative A3 regarding a road and train bridge with 2x2 lanes and 2 railway tracks, cost: 11,500 million DKK

Alternative A4 regarding a road bridge with 2x2 lanes, cost: 6,000 million DKK

Apart from the fact that the alternatives solve different transport purposes, the construction costs also vary considerably. Trying to illustrate the choice of alternative based on the individual alternative's Core Performance (CP) in the form of a cost-benefit analysis would be insufficient. Also here we can observe the tendency that 'pure' road facilities have a better transport-economic performance than facilities that include public transport. It therefore seems fair to include issues which benefit from investments in improved public transport.

At a decision conference five criteria were established and ranked according to their importance, see Table 3.2. In this case the hard method is SIMDEC which means that the resulting attractiveness scores for the four examined alternatives will only indicate their relative importance.

Table 3.2 Result of the determination and ranking of criteria during the decision conference

Criteria	Ranking according to importance	Weight
C1: Socio-economic robustness	1	0.35
C2: Impact on cities and areal use	4	0.13
C3: Impact on the environment and nature	5	0.06
C4: Impact on the regional economy	3	0.19
C5: Impact on networks and accessibility	2	0.27

The robustness of the socio-economic analysis (C1) is based on simulated B/C rates which, similarly to the other criteria, are made use of through pairwise comparisons to establish the scores under the robustness criterion.

The general process when using SIMDEC at a decision conference is that the alternatives (here four) are assessed by pairwise comparison under each criterion (here five) which allows a mathematical determination of their scores in relation to the actual criterion.

The individual criteria as shown in Table 3.2 are not equally important and the group therefore assigns each of them a relative importance in the form of a ranking. On this background it becomes possible to determine weights based on a probability-theoretical estimation (see Appendix II). Note that the Wider Performance perspective, with respect to the total weight, accounts for approximately 2/3 (from rank 2, 3, 4 and 5), whereas socio-economics accounts for approximately 1/3 (from rank 1).

As mentioned the 'performance' or scores of the four alternatives with regard to each of the criteria is done by means of a pairwise comparison of alternatives where the group answers a sequence of weightings. To exemplify the criterion on networks and accessibility is shown in Table 3.3, where A1 is first systematically compared with A2, A3 and A4 and

then A2 with A3 and A4 and finally A3 with A4. In this way the necessary information is available for a mathematical determination of the scores of the four alternatives with respect to networks and accessibility. The technique used here is known as REMBRANDT and has several advantages as compared to the original pairwise technique AHP. Thus pairwise comparisons are an important element of SIMDEC.

In Table 3.3 j,k indicates a given pairwise comparison. The preference intensity appears from the table and is attached to the individual preference values. It ranges from 0 (for indifferent) to very strong (+8). The sign + indicates a preference for j (first alternative in the pair-wise comparison, while – indicates a preference for the second alternative). Based on the above, it appears that the preference-answers must be the opposite when 'mirrored' across the diagonal where all the elements must be expected to be 0. It is also possible to use odd integers between the extreme values 0 and 8 if a preference-answer needs to be graduated.

Table 3.3 Determination of scores for the criterion on networks and accessibility:

Pairwise comparison of alternatives under criterion 5 regarding networks and accessibility:				
Pref. (j,k)	A1	A2	A3	A4
A1	0	Strong (+6)	Clear (-4)	Weak (-2)
A2	Strong (-6)	0	Very strong (-8)	Strong (-6)
A3	Clear (+4)	Very strong (+8)	0	Clear (+4)
A4	Weak (+2)	Strong (+6)	Clear (-4)	0

Such a pairwise assessment is made for all the criteria after which REMBRANDT contains a mathematical procedure that can determine the

score for each alternative. This procedure is used to determine the following scores for the criterion on networks and accessibility: A1 = 0.05; A2 = 0.00; A3 = 0.84 and A4 = 0.11. Not surprisingly, alternative A3 regarding a combined road and railway bridge has considerable impacts as reflected in the scores.

In this way we obtain the total result shown in Table 3.4. It should, however, be noted that in SIMDEC these resulting values only indicate a relative assessment of the assessed alternatives per se, while, previously, the resulting values in COSIMA could be considered absolute in the sense that the cost-benefit rate, which remains unchanged throughout the COSIMA analysis, was added a contribution based on the non-economic MCA-effects.

Table 3.4 The overall result of the SIMDEC analysis

Fixed Elsinore-Helsingborg link (alternatives)	Description (project type)	Costs in 1,000 million DKK	Total value	Rank-ing
A1	Railway tunnel (2 tracks) only passenger transport	7.7	0.09	4
A2	Railway tunnel (1 track) only freight transport	5.5	0.13	3
A3	Road and railway bridge (2x2 lanes, 2 tracks)	11.5	0.44	1
A4	Road bridge (2x2 lanes)	6.0	0.34	2

The SIMDEC analysis is integrated in the decision conference where a facilitator structures the process. It is recommended to work out a logbook that for each of the pairwise comparisons contains the arguments and discussions that lie behind the individual preference value.

Summing up of the case

Both COSIMA and SIMDEC aim to combine Core Performance (the CP perspective) with Wider Performance (WP). There are certain similarities between the two methods, but also differences which are reflected in their results. If COSIMA can be considered as an 'extended' cost-benefit analysis, where the monetary values of the, in principle, non-economic factors are determined 'internally' at the actual decision conference, then the SIMDEC analysis is built up in such a way that the cost-benefit analysis, i.e. the CP perspective, becomes a separate decision factor analogously with the other WP factors. Neither of the two methods can be claimed to be the 'most correct' one to use. However, if you have to judge this, then COSIMA will probably be best suited for a decision conference with representatives who have a technical background. Applications of COSIMA have indicated that the always visible B/C rate, which 'disappears' in SIMDEC, is considered a valuable property in many cases. On the other hand we have SIMDEC which, seen within a learning context, has appeared to be easier for the facilitator to explain to non-technical participants in a decision conference.

For both methods their purpose is to expand the CP perspective with the WP perspective. Two examples regarding relocation in the Oresund Region and a new fixed link between Elsinore and Helsingborg illustrate that it is possible to establish a decision basis in a creative way. Thus the participants can formulate and include factors that express different strategic types of consequences by drawing on judgmental and qualitative considerations that are tested in the group process.

Below a third example will illustrate the possibility to include issues regarding a desired sustainable transport development in the strategic choice task. Here focus will mainly be on stakeholder views that ought to be represented at the decision conference.

SP and sustainability

This example concerns an upgrading of EU's transport corridor Rail Baltica from Helsinki via Tallinn, Riga and Kaunas to Warsaw with further access to the central railway network in Europe. It should be observed that this case is described with more technical details in Appendix II.

The three main alternatives all express a wish for an overall desired level of improvement and consist of different components such as newly established railway sections, supplementary tracks as well as upgrading of existing sections to allow the trains to drive at a higher speed. To a varying degree, the three main alternatives (investment packages P1, P2 and P3) also include the transition from Russian to European standard railway gauge. The investment budget ranges from 979 million EUR in alternative P1, where a minimum speed of 120 km/h can be reached, to alternative P2 with an investment of 1,546 million EUR and with a minimum speed of 160 km/h to alternative P3 with full European standard to a total investment of 2,369 million EUR. The three alternatives are shown in Figure 3.8.

For the assessment of the three alternatives cost benefit-calculations have been performed, and the benefit-cost rates in Table 3.5 have been found.

As appears from the table, all three alternatives provide a quite high transport-economic result with P1 as the best. When the alternatives are only assessed based on the Core Performance perspective, main alternative 1 should be implemented. However, the complex planning problem consists in whether a Wider Performance perspective can cause main alternatives 2 or 3 to be preferable. This has been assessed in a SIMDEC analysis similar to the one described in the above case about a fixed link between Elsinore and Helsingborg. In this example focus will, however, be less on the SIMDEC analysis method regarding the CP and WP perspectives and more on the Fairness (FA) and Diversity (DI) perspectives.
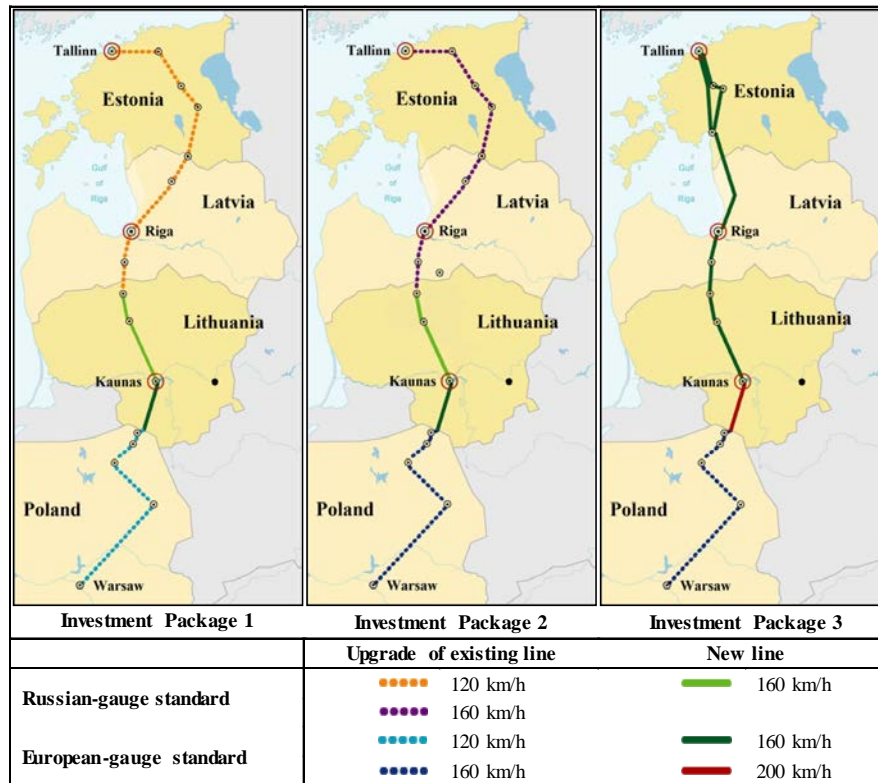
Figure 3.8 The three main alternatives (investment packages P1, P2 and P3) in the EU transport corridor Rail Baltica

Table 3.5 Benefit-cost rates for the three main alternatives

	P1	**P2**	**P3**
Benefit-cost rate	2.92	2.65	2.27

With a CP-based choice of alternative seen as an expression of a conventional approach we will focus on whether it is possible to set up a decision basis which can lead to a choice of alternative with emphasis on sustainable development. In particular, this concerns whether P2 or P3 will be the most attractive choice when emphasis is on sustainable

development. It will give rise to a description of some of the elements of a decision conference in more detail than what was the case in the above two examples. At the same time the methodological elements, which are described with a certain level of detail in the relocation case and the Elsinore-Helsingborg case, are skipped below. In this way this case forms the basis for assessing, with all the reservations it implies to use just one case, whether *systemic planning (SP) has a potential with respect to assessing sustainability.*

At the decision conference on the relocation case the participants were asked in Question 1 whether they could accept the relocation alternative pointed to as the most attractive by the cost-benefit calculation, as it would result in the highest benefit-cost rate (BCR) of the 8 examined alternatives, see Table 3.1. In principle, this is equivalent to asking whether the decision should be based on the Core Performance perspective. As described, the participants wanted to include additional issues, and thereby we are moving towards the Wider Performance perspective. The course of the Rail Baltica case is quite parallel in this respect; nevertheless it presents a very special challenge in the way that there are no guidelines that can assist more precisely in the actual assessment of sustainability, despite many years of declarations of intent and adherence to the principles of sustainable development (SD). If the conventional economically-based analysis and decision is considered as an expression of business-as-usual (BAU), the concrete challenge in the Rail Baltica case is to interpret SD and to include this interpretation when the WP perspective is worked out in the form of a set of criteria for the subsequent SIMDEC analysis.

Not surprisingly, this implies a number of difficulties that challenge the facilitator of the decision conference. "Criteria set" alone as a term indicates that a kind of 'verbal adaptation' should be made. The participants in the decision conference may prefer other terms and will typically talk about "issues of importance", "decision circumstances" or, more in line with the criteria set terminology, "other factors". In this case it can be convenient to use soft methods as shown in the right part of Table 2.1, for instance brainstorming and SWOT analysis. Both these

methods can be used after a short introduction by the facilitator. Table 2.1 also contains other methods (mind mapping, Critical Systems Heuristics, Soft Systems Methodology, stakeholder analysis and futures workshop) which can also be used here, but common to these methods is that they will be more demanding for the participants and the facilitator. On the other hand it has turned out that they can lead to a common understanding of the actual planning problem which may not be obtained by brainstorming and/or SWOT. Typically the soft methods can contribute considerably to the Fairness (FA) and Diversity (DI) perspectives.

In Table 3.5 are shown a total of 8 criteria which set out the Wider Performance perspective (WP) for the Rail Baltica case. Normally such a set is obtained by use of one or more soft methods and through in-depth discussions in the group of participants resulting in adjustments, rewording etc. Experience shows that, at first, it can be convenient to produce a so-called Long List including all the proposals, for instance by use of brainstorming. Examples from Danish and Swedish decision conferences have shown that for a complex planning problem such a Long List can contain between 15 and 25 proposed relevant criteria.

Table 3.5 Overview of the criteria in a WP perspective and SD and BAU ranking of criteria according to their importance in the strategy. The derived weights are shown in parenthesis

Criteria	Sustainability (SD strategy) ranking	Conventional (BAU strategy) ranking
Accessibility and transport networks	2 (0.20)	4 (0.14)
Promotion of EU's green corridors	6 (0.08)	6 (0.08)
Development of tourism	7 (0.05)	5 (0.11)
Impact on environment and ecology	1 (0.23)	8 (0.03)
Impact on health	4 (0.14)	7 (0.05)
Location and logistics of the company	3 (0.17)	2 (0.20)
Importance for regional development	5 (0.11)	3 (0.17)
Robustness with respect to socio-economics	8 (0.03)	1 (0.23)

It is then up to the facilitator to reduce the list to a total of approximately eight criteria. Particular attention should be given to overlapping and repetitions. It goes without saying that the resulting

criteria list with its belonging rankings based on the chosen development strategy becomes key information with respect to the further process and the final result. The degree of carefulness and creativity with which this list is set up and how relevant it is considered, including the strategy-dependent rankings made, determines to a high degree how relevant the later result will be as decision support. This issue will be dealt with in Chapter 4 with focus on the validity of a systemic planning process.

Already at this stage it can be stated that it is important that all essential stakeholders are represented at the decision conference. In case of new transport infrastructure the stakeholders are not only state and/or local authorities, but should also be the people living in the local neighbourhood and the local business community. With focus on sustainability (SD) versus unchanged development (BAU) the decision conference can be organised in such a way that one of the stakeholders explicitly represents SD thereby acting as what in this context shall be referred to as a *"sustainability advocate"*. The role of the sustainability advocate (one or more persons) will then be to ensure that all the green aspects are considered and prioritised in an SD strategy. 'Green' is here to be understood in a broad manner with the green attractivity measured as a score for each alternative for a planned infrastructure investment under the SD strategy. This score thus indicates in an aggregate way the overall contribution of each alternative (measured relatively to the other alternatives) to the overarching goal of sustainable transport development.

When organising a decision conference with a view to sustainable development (SD), it should be ensured that the process regarding the interests attached to the choice of alternative is considered both fair and inclusive. If the process and methods of analysis are accepted together with an adopted SD strategy, the result of the Rail Baltica case will be that P2 – however with a narrow margin – is preferable to P3, see Figure 3.8.

When assessing this result, its robustness should finally be taken into consideration. The last of the five mentioned perspectives forming part of systemic planning (SP), i.e. the Robustness perspective (RO), is treated in the beginning of the following and final Chapter 4. After presenting the
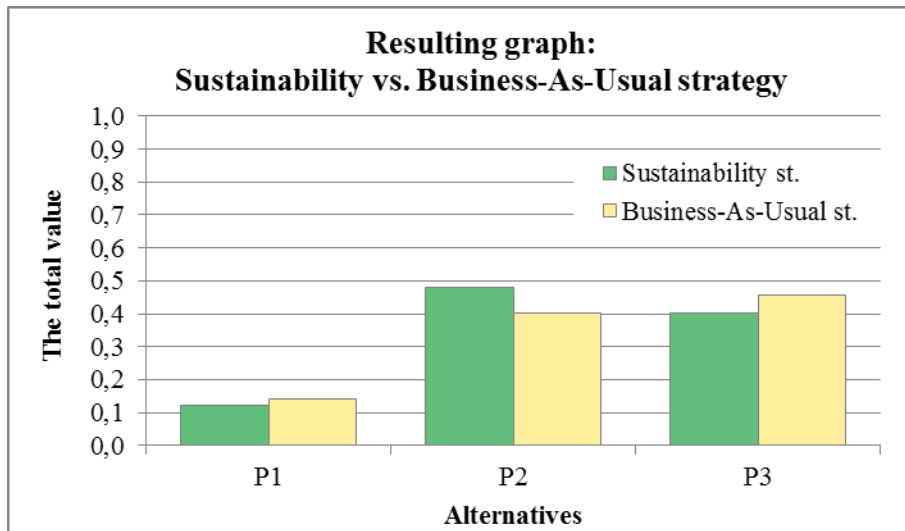
Figure 3.8 The Rail Baltica case results: With a BAU strategy P3 is the most attractive alternative, whereas P2 is the most attractive alternative when using an SD strategy

Robustness perspective, Chapter 4 will outline whether SP considered more generally can lead to better decision basis by using the five perspectives in case of a complex planning problem.

4. Better decisions – How?

White elephants and black swans

Concepts such as white elephants and black swans in connection with decisions on large investments have their own special meaning. Thus the white elephant characterises an investment which in the future will be considered totally wrong for a number of reasons which can often be summarised as the wrong project at the wrong place at the wrong time. Retrospectively, a white elephant indicates a decision on a large investment which should obviously not have been made. That it was made anyway can be due to many things which cannot always be clarified. We can for instance mention erroneous analyses, undeservedly successful stakeholders during the decision-making process, recent totally unexpected circumstances, etc. When you study the concrete decision-making process in detail, you can often add "special circumstances" in connection with the decision. All in all it can probably be stated that white elephants as opposed to nature's real elephants are not a threatened species. Bad decisions will also be made in the future. Therefore we do not talk about eradicating bad strategic decisions, no matter how wishful that might be, but about an ambition to make them less probable which, on the other hand, is in no way an unambitious planning objective.

Above we mentioned recent unexpected circumstances as a possible reason for wrong strategic decisions which puts into focus the last of the listed perspectives in the SP approach to a complex planning problem, i.e. Robustness (RO). Even with the inclusion of Core Performance (CP), Wider Performance (WP), Fairness (FA) and Diversity (DI) when handling a complex planning problem as described above in Chapter 3, it cannot be ensured that everything will not be 'overturned' as a consequence of unforeseen events. This is the domain of the black swan which in the years after the financial crisis has come to characterise a totally unforeseen event. Therefore there are special requirements to the handling of the Robustness perspective.

There is a good tradition of examining uncertainty by means of sensitivity analyses where you systematically change one or several of the important factors, for instance a higher or lower forecasted growth, or, which is a more comprehensive examination, use a number of plausible future scenarios. Analytically more refined is the use of simulation where probability-distributed factors are merged by means of so-called Monte Carlo simulation. These procedures are included in the SP tool box shown in Table 2.1.

As earlier mentioned we distinguish between the very complicated and the complex planning problem. To underline this, reference was made to a box with 'complexity walls' where for instance detail complexity, dynamic complexity and preference complexity can make even the most refined analytical approach fail. As a consequence hereof it may be advantageous to take a 'synthetic perspective' on the uncertainty of an investment project (for further information on the term synthetic perspective refer to Kahneman & Tversky's reference class forecasting). Instead of analysing the 'inherent conditions' of the concrete project you consider a number of already implemented projects which, to a varying degree, are similar to the project you are examining, and then you study how these projects have actually performed. On this background you can draw a parallel to the actual project. If for instance all the projects in the reference class have taken 10 years to carry out, you deduct that it will probably also take ten years to carry out the new project, regardless of the

possibly more optimistic estimations from the project team running the project.

Airport project at Nuuk

The above line of thought can be illustrated by means of a socio-economic study performed on the extension of the airport at Nuuk where a 2200 m airfield is to be established. As it will appear below we take both a 'synthetic view' and an 'analytical view' on the project which we will describe in the following after the introduction of two key factors.

The two key factors are made up by the construction costs of the project and by the future traffic which will be served by the airport. Both factors are crucial for the project's socio-economic return on investment. Naturally, other factors also have a role to play when deciding whether the project should be carried out or not, but with the purpose of describing the Robustness perspective focus is put on the two key factors construction costs and traffic forecast. The construction costs are the result of the preparation of a sketch project for which the various cost components have been calculated to a 'certain level', i.e. with an inherent uncertainty which is characteristic of early draft planning. Similarly, the traffic forecast (the expected transport demand associated with the improved airport conditions in interaction with the general development of the traffic system) has been determined in connection with the study. Also this factor has an inherent uncertainty.

The synthetic view consists in finding reference projects for evaluation of the Nuuk project. In Figure 4.1 is shown a total of 58 such projects selected from a project database of approximately 260 projects. The figure is a histogram where the x-axis indicates how well the actual traffic development (transport demand) has matched the expected traffic development (actual development as percentage deviation from the expected development). The y-axis indicates the frequency (percentage of the selected reference projects). The better the expected transport demand has been met by the actually observed demand, the more the columns will be centred around the 0%-value of the x-axis. The red and green colours

of the columns are used to show the deviations' influence on the socio-economic result of the project. Deviations in the red columns indicate influence in the form of a reduced benefit-cost rate (BCR) as compared with the expected BCR, while the green columns indicate influence in the form of increased BCR as compared to the expected BCR. The expected BCR for the Nuuk project was found to be 2.52 which must be considered a satisfactory socio-economic surplus. The dominance of red columns in Figure 4.1 based on the synthetic view, however, indicates that the uncertainty may be of such magnitude that even a BCR of 2.52 as initially calculated does not secure a robust result.
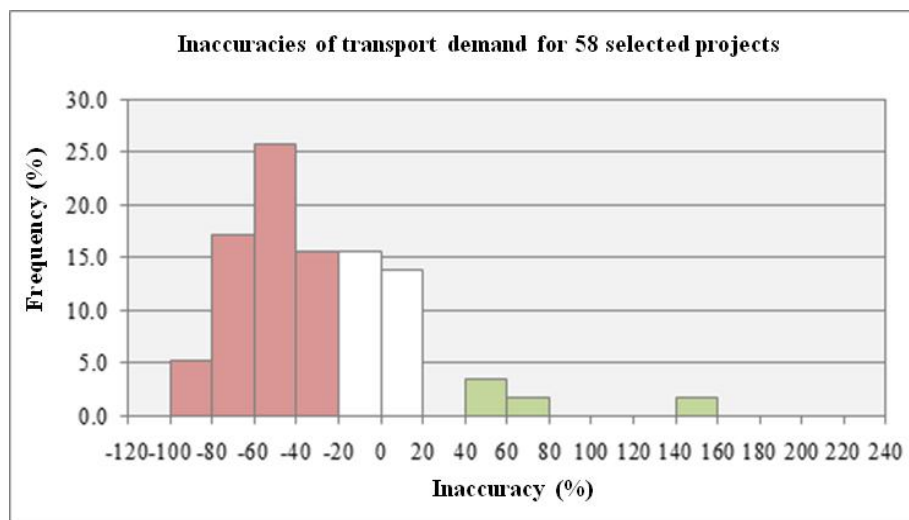
Figure 4.1 Histogram for synthetic view on the Nuuk case

The synthetic view can be supplemented with an analytical view where experts with good knowledge of the Nuuk project are involved with a technique which is under development. This technique makes use of overconfidence theory from mathematical psychology where the experts' statements about Max and Min values are used to adjust the histogram in Figure 4.1. In case of the Nuuk project it resulted in the histogram shown in Figure 4.2 where the width has been scaled up by a factor 1.17. In practice this is done by including the RO perspective as part of a decision conference. As was the case with the previously described elements of a

decision conference, the conference is conducted by means of a facilitator. The only expertise required from the experts is expertise attached to a conventional Core Performance analysis based on a cost-benefit analysis and no knowledge on neither reference class forecasting nor over-confidence theory is needed.

It can be stated that the information on socio-economic robustness that appears from Figure 4.2 has arisen by means of a synthetic view modified by the experts' analytical view on the concrete project.
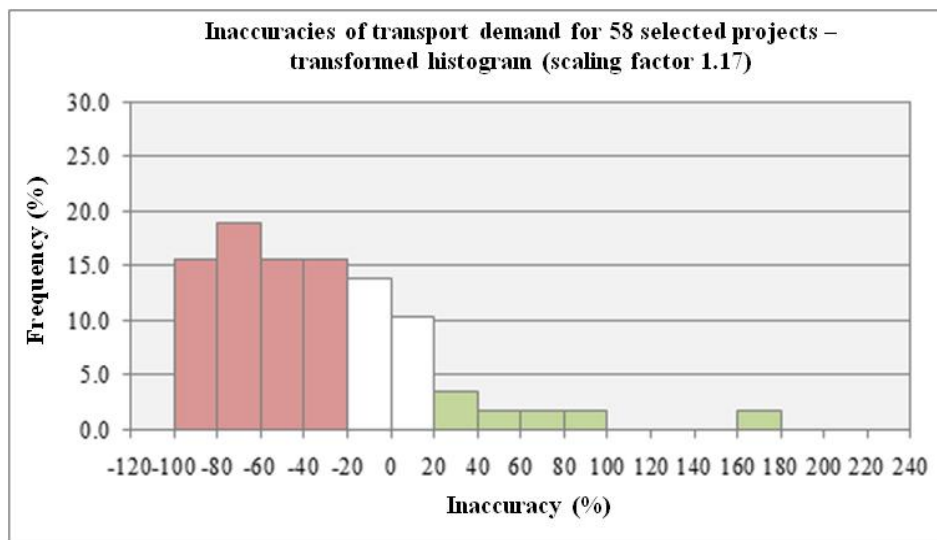
Figure 4.2 Modified histogram for synthetic view on the Nuuk case by use of experts

Subsequently, this knowledge is utilised by means of Monte Carlo Simulation which leads to the Certainty Graph (CG) shown in Figure 4.3.

Nor in this case is it necessary for the participants in the decision conference to have detailed model knowledge of the SIMRISK method (for simulation-based risk analysis). The essential thing is to be able to interpret the CG curve. Figure 4.3 shows a graph where the x-axis indicates the BCR value, while the y-axis indicates the probability that the BCR will be bigger or equal to the value at the x-axis. With respect to cost-benefit analysis it is important that the BCR is bigger than or
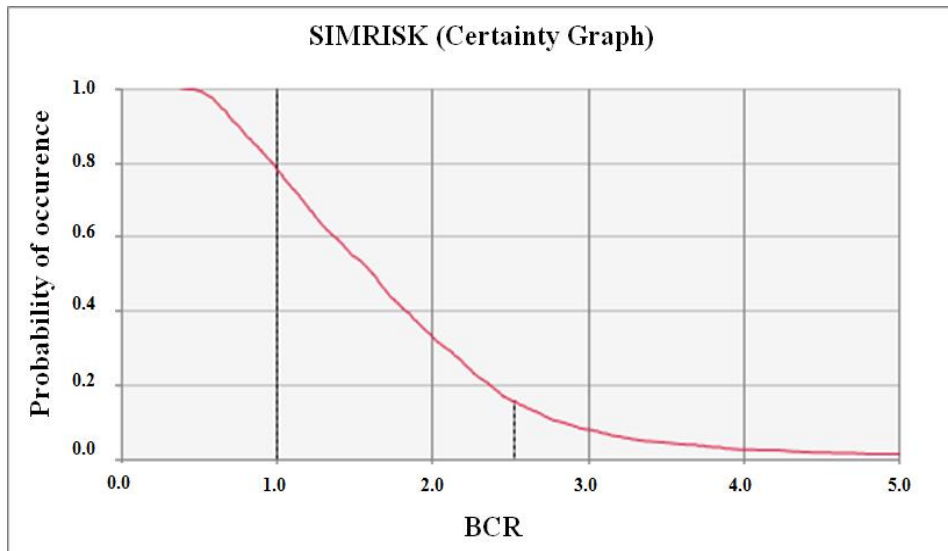
Figure 4.3 Certainty graph for the Nuuk case. A BCR of at least 2.52 has a probability of approximately 15% while the curve shows a probability of approximately 80% to obtain, as a minimum, a BCR value of 1

equal to 1. As mentioned above a BCR of 2.52 can be considered as satisfactory and conventionally it will be assessed as an expression of substantial robustness.

Nonetheless, the above analysis which uses both an external synthetic view and an internal analytical view shows that for the decision-makers basing their decision on a robustness perspective there is good reason to take into consideration a result that shows that there is only a probability of 80% to obtain a BCR value bigger than or equal to 1. This is the critical cut-off value in socio-economic theory between implementing and not implementing. In addition, the analysis, which gives food for thought, shows that a BCR of at least 2.52, i.e. the result of the cost-benefit analysis, only has a probability of 15%.

Does it then mean that the Robustness perspective (RO) can uncover and handle the uncertainties associated with large projects by means of SIMRISK and similar techniques? That is hardly the case since the knowledge base made use of is retrospective. The reason why the black swan is black is that it symbolises what could not be predicted. Just as

white elephants as opposed to nature's elephants are not a threatened species, nor is the black swan.

Can we then maintain that applying systemic planning (SP) with the use of the Robustness (RO) perspective in interplay with Core Performance (CP), Wider Performance (WP), Fairness (FA) and Diversity (DI) perspectives will lead to better joint decision-making? This will be illustrated below by first considering possible pitfalls and biased decisions and then by a characterisation of creative and sustainable decisions.

Pitfalls and biased decisions

To reiterate systemic planning (SP) is a search-learn process that uses five different perspectives to explore a complex planning problem. The various perspectives have been described in the above examples where the general idea has been to address the perspectives one by one so a full picture of the SP potential could be successively developed. In this way the CP perspective was the first perspective to be introduced with its foundation in cost-benefit analysis (CBA). Below as an introduction to possible influence from different types of biases in SP, it is first considered what kind of role CBA ought to play in SP.

The role of the cost-benefit analysis in SP

Undoubtly, cost-benefit analysis (CBA) has played a big role over the years when discussing the large investment decisions in the field of transport. CBA traces back to the 1930s in the United States and Roosevelt's New Deal and the construction of dams. It was introduced in Europe for transport decision-making in the 1960s – in England for the London-Birmingham motorway study and in Denmark in connection with the Lyngby bypass road project. The CBA approach used today follows more or less the same basic principles as applied when brought to Denmark. However, along the way it has been refined, among other things with the Danish Road Directorate's inclusion of environmental impacts at

the end of the 1970s and afterwards in connection with the Ministry of Transport's manual from 2003 and with an updated version published in 2015.

The CBA concept has a welfare-economic foundation built around the willingness-to-pay concept associated with the use of a new traffic facility. The method has obtained a reputation of being an objective decision support tool, which, however, in theory can be contested to a varying extent. For instance, a new road facility resulting in saved travel time from A to B often means that more travellers want to use this new option. According to the CBA method and the welfare-economic rule called The-Rule-of-a-Half, each new road user will get a benefit which on average is equivalent to the half of the travel time benefit assigned to the road users already using the road. In this case you should not pay too much attention to the factor of a half, but rather to the fact that increased car traffic is actually calculated as a benefit according to the CBA method which, due to the increased congestion on the road network, may in a wider context well allow for other interpretations.

Maybe as a result of its *apparent* objectivity and scientific character the CBA method has throughout the years obtained enthusiastic supporters but also for the same reason bitter opponents. No doubt CBA should play an important – but maybe more balanced role in many cases – as an expression of what in SP is referred to as the Core Performance perspective. Therefore as part of the SP approach to planning *a third position is proposed as a point somewhere between the two above mentioned extremes*, i.e. as a decision factor to be assessed against the other factors in a decision conference.

In the cases treated in Chapter 3 the COSIMA and SIMDEC methodologies were applied to make use of the Core Performance (CP) perspective in combination with the Wider Performance (WP) perspective. Specifically in the example about relocation, a Core Performance (CP) perspective was supplemented by a Wider Performance (WP) perspective, which was also the case in the subsequent example about a new fixed Oresund link between Elsinore and Helsingborg. The difference between the two examples consists in that the first one is based on a combined

cost-benefit and multi-criteria analysis (combined CBA and MCA) called COSIMA which can generally be described as an "extended CBA", whereas the next example is based on a combined CBA and MCA called SIMDEC where the socio-economic aspect (the CBA component) is part of a multi-criteria analysis as one of several criteria. Is it then irrelevant whether we use COSIMA or SIMDEC?

A reply to this question can be found in the method narrative behind the two methods, i.e. the 'language' used by the method and the way in which the facilitator presents the various preference questions to the participants in the decision conference. While COSIMA is centred around the CP perspective based on which additional information about the set of future-oriented choices is built up, this is not the case of SIMDEC which has a more neutral approach to the decision factors or criteria involved. This 'decentering' of the role of the CP perspective and hereby the role of CBA may – so tells the experience with SP sessions – appeal to some decision-makers but not to others.

Cognitive bias

Within the field of cognitive bias one of the types of bias which is often mentioned is *Anchoring*. Hereby is meant that the information which is provided first and which is determined in relation to a decision problem will be used as reference when the decision is to be made. An example can be the first price you propose (equivalent to a salesman's smart formulation "How much will you pay?") as this will be of great importance for the final price.

Another important cognitive bias is *Framing* which is about the importance of how the choice situation is described. Which factors are included and which of these address a gain or a loss. An early result (Kahneman & Tversky) from the research into cognitive bias was that there is no symmetry in people's evaluation of the chance of profit as opposed to the risk of loss. Thus the same amounts in the form of expected gain and expected loss do not set off each other, since the risk of loss is

assigned greater importance which can be summarised in the concept of risk avoidance ("You know what you have but not what you will get").

A third important cognitive bias is *Focusing*. Here, apparently, 'too much' weight can be assigned to a single factor which then controls the decision-making ("No matter what, I think ..."). Naturally, it cannot be required that all possible factors should form part of an evaluation. However, which factors to consider are a concern of the key stakeholders that should all be represented at the decision conference.

A fourth important form of bias is *Confirmation*. You do not consider the group process at a decision conference as a learning process; instead you let yourself be controlled by how you have already made up your mind with respect to various issues ("Previously we have had very good results by …").

Each of the various types of cognitive bias contains pitfalls for the individual participant and for the ongoing group process led by the facilitator. The latter must inform the participants about the working of biases and make it sufficiently clear that the goal of the group process is collective learning built on open discussion where positions and weightings etc. are based on the best argument. At the same time it cannot and should not be ignored that strategic bargaining and discussion is part of the process when people meet to discuss and decide jointly upon an important issue. This should be handled by means of a justifiable process which we, in summary, can see should be within the limits of what is considered a democratic procedure.

Bottom-up organisation of SP decision conferences

With the pitfalls and risk of mistaken decisions due to the various types of cognitive bias and with the rules typical of a democratic context, a few suggestions of how to organise SP decision conferences shall be mentioned. In general such conferences require preparation and time, both for those responsible for their preparation and for those who carry them out, but also for those participating in the conferences. In this connection you may for instance consider the planning of a large regional road facility

which is initiated locally. The planners may begin with the testing of a number of alternatives at a decision conference or planning workshop more informally with the presence of at least the people living in the municipality, the business community and the technical administration. If this conference points to diverging views as to what is the best alternative, a new conference, after a possible reconsideration of alternatives with participants that represent regional and possibly national interests, can be held. Such a *bottom-up approach* towards more formal, legally based decision-making seems both flexible and democratic as adjustments and propositions can illuminate the planning onwards to a decision conference with all the involved parties.

However, the essential question remains: Will we get better decisions using an SP approach as outlined above, or might we just as well stick to a conventional approach based on primarily the cost-benefit analysis?

Creative and sustainable decisions

Put crudely you may say that a conventional approach to the solution of a complex planning problem is based on a Core Performance approach supplemented on an ad hoc basis with other relevant information about the problem on hand, whereas an approach based on systemic planning (SP) is based on an interaction between the five perspectives listed below and which are used in a group process named a decision conference.

1. Core Performance (CP)

2. Wider performance (WP)

3. Fairness (FA)

4. Diversity (DI)

5. Robustness (RO)

The idea behind the five SP perspectives is to provide a more comprehensive approach than each of these would do, e.g. CP alone. So which qualities or lack of qualities can we assign to SP, for instance with respect to the validity of the methodological and procedural aspects? How can SP help us think 'out of the box' so that we can make more creative and sustainable strategic choices?

Creativity

Creativity is not characterised by being a concept which can be defined with a more or less precise formulation. However, creative problem-solution is characterised by a series of features which are listed below:

- The ability to question presumed assumptions

- The ability to see and interpret contexts in a new way

- The ability to see and recognise alternative perspectives

- The ability to combine goals and means

- The ability to consider new possibilities and risks

If these characteristics are paid full attention to when handling a complex planning problem, this may justify perceiving the activity as a kind of 'out of the box planning'.

Above we have described the very important role that cost-benefit analysis (CBA) has had and probably still has in connection with transport planning studies. This should be confronted with the possible advantage of applying SP based on the individual use and interaction of its five different perspectives. Various issues become of interest in this respect.

Which importance for instance can be attributed to the fact that the Core Performance perspective (CP) of the cost-benefit analysis is embedded in a Wider Performance perspective (WP)? With reference to

the types of bias described we can say that the risk of Anchoring influence is reduced. Thus at an early stage of the decision conference a list of criteria is set up, and such a list can be seen as a first sketch of a framework which can provide *a more holistic approach to the complex planning problem.* This may lead to a more balanced use of CBA results.

However, at the same time there is also a risk that the bias type Framing will occur. As a result of the discussions behind the setting up of the list of criteria in some cases a common understanding of a structure in this list of criteria may be obtained which, by choice or accident, assigns degrees of importance to the individual criteria. Whether that will be the case depends – apart from the facilitator's "Now you should notice…" – on the composition of the group in question. Are there for instance individuals or alliances that influence the ongoing discussion and the choices made? The participants can have very different experiences or administrative positions, etc. The skilled facilitator attracts the necessary attention to the framing issue by raising the group's awareness that it should consider itself as a group composed by different stakeholders. At the same time the facilitator should underline that this is not a problem but rather a potential to see the actual planning problem from different points of views and values.

The definition and addressing of the problem from different points of view and values, which must of course be justifiable, furthermore show how the Framing bias can be reduced by applying the Fairness (FA) perspective. Basically FA draws attention the question whether "Something or somebody has been forgotten …". Then again such a situation can be remediated by introducing the Diversity (DI) perspective in the further discussion.

The DI perspective may lead to a reconsideration of earlier steps of the deliberations which can have significant influence on the final result. One or several new alternatives may for instance be formulated. The SP approach is therefore through its *iterative approach across the SP perspectives* supposed to ensure that the most relevant alternatives are included in the planning. The final choice in the set of future-oriented choices may can for instance be affected by one or more members of the

group now having realised that a so far somewhat disregarded alternative might after all be of interest. In this way the bias type Confirmation can be avoided.

In the phases described, there is hardly any doubt that the group will benefit from having creative and innovative members. In addition, there are also group techniques which can be utilised with considerable advantage, for instance the techniques Soft Systems Methodology (SSM) and Critical Systems Heuristic (CSH), see Table 2.1. As concerns the Fairness (FA) and Diversity (DI) perspectives numerous examples show the strength of these two soft methods. However, it should be noted that both methods can be rather time-consuming. Furthermore SSM is very dependent on the knowledge and skills of the facilitator, while CSH, highly dependent on the actual planning case, can be used in an abbreviated version with fewer CSH-questions. This makes it worthwhile to consider CSH even with time limitation.

When the group has been through a process drawing on the CP, WP, FA and DI perspectives and perhaps feel like being 'almost' able to indicate the most attractive alternative, one of the five SP perspectives is still missing, i.e. the important Robustness perspective (RO). Apart from the fact that a decision (or a decision-support proposal) should be seen as the result of a creative process, it is also important that it concerns a robust planning alternative. The test of robustness in connection with complex planning problems contains elements based on detail complexity, dynamic complexity and on what was previously described as preference complexity. With the facilitator supported by an analyst, see Figure 2.2, it is important that tests for parameter variation (sensitivity analysis) and feasibility risk (Monte Carlo Simulation, possibly with statements from experts) are carried out possibly under different scenarios. In this way it is tested if for instance the socio-economic return on investment is robust. It may be noted that where the Robustness (RO) perspective implies mainly quantitative methodology, the Diversity perspective (DI) can be seen as representing a kind of qualitative robustness testing.

Specifically as regards preference uncertainty it can be considered as tested under the Fairness perspective where alternative attitudes and sets

of value are counterposed. However, it cannot be stated that the preference uncertainty has been tested sufficiently. That is because the attitudes and preferences can undergo a principally unforeseeable development over time. And completely unexpected things can happen. This is evidenced by the occurrence of white elephants and the black swans as mentioned earlier. Awareness of influence from detail, dynamic and preference complexity should help promote the creativity of group members in their deliberations.

Sustainability

Sustainability as a timely overarching planning goal accounts for a special type of complex planning problems. Initially, we can establish that a sustainable planning solution is not just a very complicated planning problem, but indeed a complex problem. As stated earlier the use of mathematics in decision support known as operations research (OR) includes highly developed algorithms, which should, however, be seen as primarily associated with complicated and not complex problems. An essential difference consists in the fact that complicated mathematical models have causality as a prerequisite, which is not the case for mathematical models used to describe complex systems. Back in the 1960s it was intended to develop the latter by creation of so-called system dynamics models that aimed to capture different sections of a huge system by setting up an overall mathematical context filled in with interdependent first order partial differential equations. A heroic Danish experiment was made in the mid 1970s to develop a system dynamics model for the traffic sector. The model was named the T-ATV model after the commissioning party, the Danish Academy of Technical Sciences. Nevertheless, the model was not used as much as the total amount of ingenuity and work invested in the model could have justified. A short and maybe a little too rigid evaluation of the T-ATV model can consist in that *the complexity inside the model did not represent the complexity in the outside real world sufficiently well.*

Which role does this knowledge play for systemic planning as described in this context? By means of good analogy you may say that both the system dynamic mathematical model (SDM) and systemic planning (SP) with described processes and methods focus on a given socio-technical system. However, an essential difference consists in the fact that SDM due to its very nature has a socio-TECHNICAL focus, whereas SP has a SOCIO-technical focus, even though SP has previously been described as an interaction between decision analysis, group processes and information technology. In SP the learning from the group process is the central element which is supported by techniques and IT. Especially, this learning process is furthered by using and comparing five perspectives which are basically *five highly different epistemic lenses* (modes of enquiry, see Appendix I) with distinct cognitive potentials. The accumulation of knowledge can be carried out with a limited use of techniques. Furthermore these SP techniques will generally take on a primarily 'supporting' function as compared to the normally 'optimising' function in case of a purely analytical problem treatment.

With sustainability seen as a complex problem the complexity first and foremost relates to the social system and what could here, taking a synoptic view, be called the governance aspect. The systems theory for social systems is probably most strongly represented by the German sociologist Niklas Luhmann's *Soziale Systeme* from 1984 (and an English version from 1995). An unsubtle consideration could be that complex planning problems owe great part of their complexity to precisely the fact that the concrete problem must necessarily be coupled to a complex, real world. When sustainability was introduced above as a complex planning problem it is due to the fact that precisely for this kind of problem detail complexity, dynamic complexity and preference complexity are interweaved in a way that makes delimitations and manageability particularly challenging.

In the Brundtland report (1988) sustainability is defined as: "The development that meets the need of the present without compromising the ability of future generations to meet their own needs". A somewhat later

definition (2005) says: "Sustainability is a characteristic of dynamic systems that maintain themselves over time".

If you would like to develop the latter definition you could substitute "maintain" by "maintain and evolve". In a sustainability perspective development is, for better or worse, of utmost importance.

Here we will distinguish between a *top-down approach* to the sustainability issue and a *bottom-up approach*. Roughly speaking a global sustainability issue such as climate change is properly approached top-down. To be argued here is that this top-down approach may well benefit from being supplemented with a bottom-up approach on an ad hoc basis. Here SP and other group dynamic learning concepts may play a role in connection with the handling of complex decisions, not just within the transport sector, but also within sectors such as energy and environment. For each of these sectors, the bottom-up approach must be embedded in a proper governance context.

Whereas *complicated socio-technical tasks* are today solved by means of an OR based method making use of optimisation mathematics, *complex socio-technical tasks* might benefit from the use of processes and methods which further a collective learning process with the purpose of obtaining the necessary knowledge and thereby providing relevant decision support. In this book, SP has been presented as an example and suggestion concerning the way this group learning process could be organised. It is worth noticing that mathematical methods are of course used but primarily as knowledge generating elements in the collective learning process.

As regards the use of SP in connection with sustainable transport planning we suggest that the group undertaking a decision conference should include a *sustainability advocate* who has the role as a stakeholder for the next generation. As previously shown in the Rail Baltica case this can lead to a sustainable solution up for consideration by decision-makers to replace a business-as-usual solution. Here the essential thing is that in the concrete set of future-oriented choices there is a proposal which is the 'most' sustainable one. This information should be available for the decision-makers that are in the position to decide about the alternative to

be implemented. The Rail Baltica case is treated in more detail in Appendix II.

In the research project named SUSTAIN about national sustainable transport planning (2012-17) funded by the Danish Research Council (now Innovationsfonden) work has been carried out with a model where the list of criteria in relation to a major construction project is subdivided into criteria on economic impacts, criteria on environmental impacts and criteria on social impacts. An example is shown in Figure 4.1.

In the SP process such a division of the criteria can among other things be used by the sustainability advocate. How weights are assigned to the criteria, for instance in a SIMDEC analysis, must depend on the concrete learning process taking place in the decision conference (DC). It is worth

Criteria

1. Economic

1.1 Competetion on transport markets
1.2 Contribution to EU´s core network
1.3 Effect on tourism
1.4 Free movement of goods
1.5 Integration of European tranport market
1.6 International ties and and coherence between countries
1.7 Location of companies and logistic centers
1.8 New technology
1.9 Regional development
1.10 Property rights/land-use
1.11 Labour market

2. Environmental

2.1 Animal welfare
2.2 Ecosystems and biodiversity
2.3 Existing assets and resources
2.4 Local air pollution and air quality
2.5 Noise
2.6 Oil dependence
2.7 Renewable energy
2.8 Safety
2.9 The climate/global warming
2.10 Water quality and resources

3. Social

3.1 Cultural heritage
3.2 Gender equality
3.4 Mobility by public transport
3.5 Security
3.6 Social inclusion
3.7 Territorial cohesion
3.8 Townscape
3.9 Transport network and accessibility
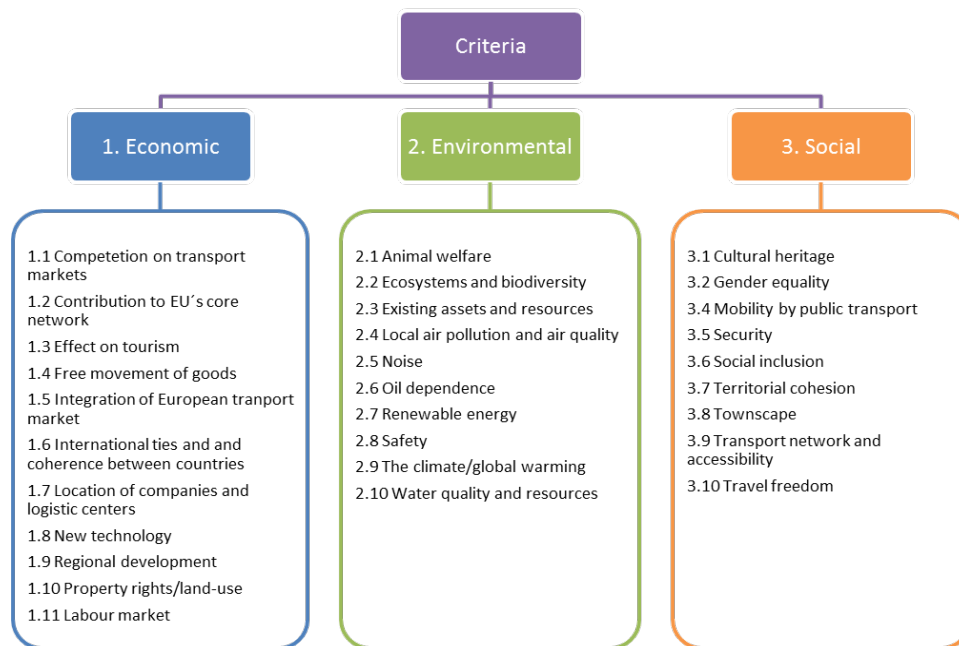3.10 Travel freedom

Figure 4.1 An example of a list of criteria divided into the subgroups economic, environmental and social impacts

noticing that here there is no overarching causal relationship, and essentially each group process is unique. However, it can be a good idea to keep a logbook which describes the DC with special emphasis on questions and their related assessment answers. This shows what the participants have experienced as being of great importance and where stakeholder inputs have differed.

It has previously been outlined how group processes can be initiated and carried out locally and tentatively with participation of for instance citizens' groups and the technical administration of the municipality involved. Based on this and dependent on the actual case a new group process with non-local stakeholders (region, state, EU) represented and with the planning material further developed can take place later.

In SUSTAIN case work has been carried out that illustrates the possibilities, pitfalls and challenges when using such an approach. For the sake of good order it can be added that this part of the research is mainly undertaken in the method part of SUSTAIN. Another part of the project has worked with sustainability indicators which are of course important input to the method part. These parts are both associated with a part regarding institutions and governance conditions. This part seeks to link and utilise the more technical elements in SUSTAIN.

Overall findings

In this book it has been argued that creative and sustainable decision making – overall in the title of the book abbreviated as *Gren Decision Making* – can be promoted by the use of systemic planning (SP). This can be achieved by engaging planners in the use and interaction of five perspectives (Core Performance: CP, Wider Performance: WP, Fairness: FA, Diversity: DI and Robustness: RO) which in tailored combinations are applied to explore and unfold an actual complex planning problem. As a complex planning problem differs significantly from the complicated problem and its OR-based *analytical solving*, the SP approach has an

emphasis on supported group processes that can lead to *collective learning* about the complex planning problem.

In this respect the decision conference – also when it is 'just' a preparing planning workshop – is at the core of systemic planning. Under that view and based on a number of SP applications and sessions from the last decade the SP approach can, roughly seen, measure its amount of success in the way the participants change from being maybe uninformed and *detached* as regards the actual complex planning problem to becoming informed and *involved* in a joint agreement. This may simply be interpreted as better and creative decision making. Implicit in such a transformation of group members are also the possibility of still greener strategic decisions to be made.

Appendix I: Details on SP learning

SYSTEMS SCIENCE AND FIVE MODES OF ENQUIRY AS BACKGROUND FOR THE FIVE PERPECTIVES APPLIED IN SYSTEMIC PLANNING

Systems science as three waves

In [1], [2], [3] and [4] systems science or also referred to as systems theory is treated as regards its possibility to guide intervention of complex problems. In [2] and [4] the development of systems science is described and exemplified as three waves of development presented specifically as a first wave with *systems as reality*, a second wave with *systems as constructs*, and a third wave with *systems seen as representations*. In the first wave (around 1930-1980) systems are perceived as 'something out there', in the second wave (around 1980-2000) as 'something conceived in the mind' and in the ongoing third wave (2000-present) as a kind of representations of 'regimes of different complexity'. These definitions and their particular backgrounds as described and argued in detail in the references have laid the foundation for a kind of 'cognitive billboard' which indicates *what and how we can learn under specific circumstances*, with the latter defined by five different research orientations: functionalist, interpretive, emancipatory, postmodern and complexity.

Table 1 and 2 shows across a double-page these five research orientations being set against each other so it becomes possible to compare their individual 'cognitive capabilities' for different features. Each research orientation represents a distinct way of accumulating knowledge, see the five colums, while each horizontal row for each feature indicates five different ways (across the columns) of approaching a particular aim of knowledge gathering. These aims can concern, for example, basic goal, method, etc. Each cell then represents some cognitive endeavour for a given combination of feature and research orientation.

Table 1 Characteristics of functionalist and interpretive research approaches representing the first and second waves of systems science

Features	FUNCTIONALIST	INTERPRETIVE
BASIC GOAL	Demonstrate law-like relations among objects	Display unified culture
METHOD	Nomothetic science	Hermeneutics, ethnography
HOPE	Efficiency, effective-ness, survival and adaptation	Recovery of integrative values
ORGANISATION METAPHOR	Machine, organism, brain, flux and transformation	Culture, political system
PROBLEMS ADDRESSED	Inefficiency, disorder	Meaninglessness, illegitimacy
NARRATIVE STYLE	Scientific/technical, strategic	Romantic, embracing
TIME IDENTITY	Modern	Premodern
ORGANISATIONAL BENEFITS	Control, expertise	Commitment, quality of work life
MOOD	Optimistic	Friendly
SOCIAL FEAR	Disorder	Depersonalization

Note: Tables 1 and 2 are to be read together horizontally so the features in Table 1 can be seen as continued in Table 2

Table 2 Characteristics of emancipatory, postmodern and complexity research approaches representing the current third wave of systems science

EMANCIPATORY	POSTMODERN	COMPLEXITY
Unmask domination	Reclaim conflict	Explore unknown territory
Cultural and ideological critique	Deconstruction, genealogy	Integrate complexity and simplicity thinking
Reformation of social order	Claim a space for lost voices	Contingent insights that will mean "a difference"
Psychic prison, instruments of domination	Carnival	The panopticon with a restricted view
Domination, consent	Marginalization, conflict suppression	Open-ended, wicked and hypercomplex problems
Therapeutic, directive	Ironic, ambivalent	Multi-dimensional, eclectic
Late modern	Postmodern	Hypermodern
Participation, expanded knowledge	Diversity, creativity	Awareness, alertness
Suspicious	Playful	Curious
Authority	Totalization, normalization	Constrained reasoning and living

Note: The characteristics of the complexity research approach from [5] were added to a table by Jackson which again was based on a table by Alvesson & Deetz [6]

As described the double-page table lays out a pattern including a multitude of different 'cognitive cells'. One can see this as a kind of 'cognitive billboard' that can convey advice on how to 'tackle' different tasks. In SP it has been used to define modes of enquiry (MOEs) that are behind the five perspectives made use of in the group process referred to in the main text as a decision conference but often also just serving as a kind of structured planning workshop.

Modes of enquiry for learning in SP

Although the double-page table represents three waves of systems science this does not mean that one wave has replaced another. It is better to see the result of the development as having resulted in five different research orientations that are presently available.

Effective group learning will require that we deal with the complex planning problem in an unconstrained way. This means that all the five modes of enquiry (MOEs) ought to be adopted at least to begin with. In practice we seek to include in principle a 'sufficient' range of matters that we judge as important for the actual planning task.

Below the five MOEs are reiterated with some consideration of their main use when placed in a context of planning and strategic decision making:

MOE 1: FUNCTIONAL aiming at examining Core Performance (CP)

MOE 2: INTERPRETIVE aiming at examining Wider Performance (WP)

MOE 3: EMANCIPATORY aiming at examining Fairness (FA)

MOE 4: POSTMODERN aiming at examining Diversity (DI)

MOE 5: COMPLEXITY aiming at examining Robustness (RO)

With each SP perspective rooted in a research orientation that is well-established in systems science particularly but also generally in common scientific-explorative activity, we can state that the SP perspectives represent validity claims – each of these with a particular orientation as concerns knowledge gathering and accumulation – that provide the overall SP process with a foundation that ought to be recognised. Recognising also that each perspective is meant to inspire and guide exploration along one particular axis of insights, the collective search and learning – the results of which are successively debated among the participants – can be expected to enhance creativity due to not least the confluence of different apects.

To assist the group process and its learning both hard and soft operations research methodology are applied, see Table 3.

Table 3 The five perspectives of SP enquiry and OR methodology

Systemic planning (SP): Five perspectives	Mainly involves the following OR methodology:
CORE PERFORMANCE (CP)	Hard methodology
WIDER PERFORMANCE (WP)	Hard and soft methodology
FAIRNESS (FA)	Soft methodology
DIVERSITY (DI)	Hard and soft methodology
ROBUSTNESS (RO)	Hard and soft methodology

Applying SP and its five perspectives seems to holds two promises [2]. One is related to *decision awareness*: SP is set out as a search-learn approach and not as a panacea that will guarantee the quality of the final decision making; the other is related to *decision ownership*: SP may have a role in providing a group with a sense of ownership towards the SP outcome in the way it assists the group members in moving from being detached to being involved in the decision recommended. Both these promises are seen as valid reasons for testing the learning potential of SP.

The idea of SP is not to enable decision makers to make the right decision but to assist decision making in such a way that an informed decision may be taken. In raising the group's awareness and moving the participants

towards involved decision making in an SP process will typically lead to questions of an open type and their answers will have implications for the structuring of the further SP process ahead. Characteristic of such questions in a decision conference is always: could or should this be otherwise? Characteristic of the process is also that later on, in case of new insights, the possibility exists of feeding back into the sequence of considerations and altering the inputs already made. In this way flexibility is built into the process.

Findings

A number of SP application cases indicate that participants in decision conferences feel comfortable with approaching complex strategic choices by using SP. At the end of each decision conference (DC) conducted by the Decision Modelling Group at DTU Transport an evaluation question-naire has been distributed to the participants and returned with generally very positive responses. In a theory context these responses, also containing constructive suggestions made use of in various ways, show as a relatively stable overall finding that in the course of SP activities and the concurrent deliberations of the DC participants, *detached understanding and deciding* seems to recede and be replaced by *involved understanding and deciding* about the complex planning task dealt with. This is seen as a kind of positive litmus test as regards the quality of the learning in the group process. Needless to say: In SP learning as with many other things the proof of the pudding is in the eating …

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Appendix II: Details on SP modelling

A SUSTAINABLE-TRANSPORT-DEVELOPMENT SCENARIO (SD) SET AGAINST A BUSINESS-AS-USUAL (BAU) SCENARIO: THE RAIL BALTICA CASE

This appendix, which is based on [1] and [2], treats an example of SP modelling in some detail. The focus is on decision making about sustainable transport infrastructure planning, in which long-term economic, social and environmental impacts are taken into account. Specifically the impact on decision making from applying valuation based on a sustainable-transport-development scenario (SD) as set against a business-as-usual (BAU) scenario is examined with a focus on the decision support modelling. The latter is thought to complement the book's main text about application of systemic planning (SP) principles on the Rail Baltica case.

To incorporate a variety of impacts for sustainable decision-making, we propose a decision support framework that applies the SIMDEC method (simulation and multi-criteria analysis for decision making) to examine an explicit sustainability strategy in a decision conference. Such a strategy may be seen as useful because it allows the decision-makers to determine the best alternative from the sustainability point of view. The evaluation is based on criteria identified as relevant for the decision to be made.

The decision support framework stems from a case study of the Rail Baltica railway line through the Baltic countries and Poland, where the best sustainable option out of a set of investment package proposals was found. This demonstrates that such a framework can provide a valid and potentially useful tool for assessing decision problems in sustainable transport planning, where the rail case treated is just one example.

The appendix is organised as follows. First the decision support framework is introduced and the principles behind the methodology are described. Then the Rail Baltica case study from the main text is presented

more detailed. Finally, the results and the validity of the proposed decision support framework are discussed and some findings are set out.

An example of an SP modelling framework

Decision-making in transport planning is often a complex process due to the constraints, multiple impacts and large number of stakeholders that combine to make the problem situations difficult to understand and assess. Addressing sustainability issues adds to the complexity of transport planning situations. So, to deal with this complexity, we believe that a multi-disciplinary and multi-participatory approach is needed.

The main scope of the proposed decision support framework is to undertake a comprehensive sustainability assessment of a large transport infrastructure project, in which a variety of criteria and stakeholders' views of their importance must be taken into account. It is a model- and process-based framework in which the assessment is conducted through a process of interaction at a decision conference. In this way, different viewpoints are integrated through a multi-methodological approach to decision making. The SIMDEC decision support framework for the comprehensive assessment is illustrated in Figure 1. The methods made use of are described in the sections below.

The SIMDEC Approach

The main scope of the SIMDEC approach is to embrace both economic and strategic impacts when assessing large transport infrastructure [1], [2]. In this regard, the approach explicitly includes the various criteria representing the different dimensions of a decision problem that need to be taken into account, rather than focusing one-dimensionally on just economy as in CBA. The approach is based on multi-criteria decision
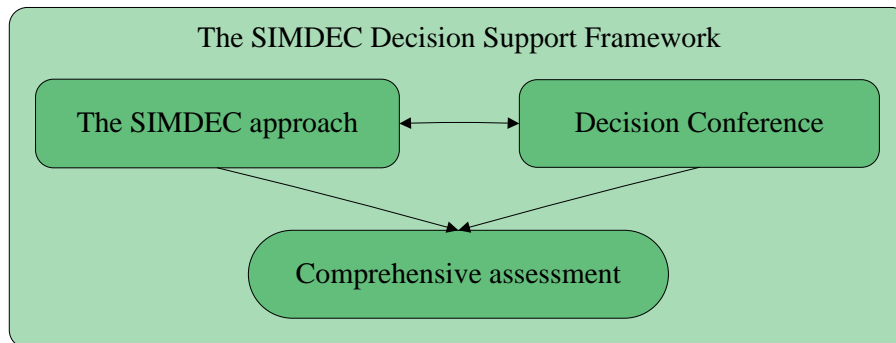
Figure 1 The SIMDEC decision support framework which exemplifies a possible application of the SP principles

analysis (MCA) with special focus on risk analysis as regards the feasibility of each project alternative. Feasibility risk assessment (FRA) aims at accounting for the uncertainties underlying the two major impacts of every large transport infrastructure: construction costs and travel-time-related benefits. The results of FRA are used as one criterion in a set of decision criteria in the MCA to depict the overall economic performance of each alternative. The main idea behind the use of the SIMDEC approach for sustainability assessment is to assess the impact of the alternatives using the criteria defined in relation to sustainable transport development. The main principles of the SIMDEC approach for sustainability assessment are presented in the workflow shown in Figure 2.

Cost-benefit analysis (CBA) is a common method for providing decision-makers with an economic assessment of the project alternatives expressed on a monetary scale. However, the issue of uncertainty appears as one of the main shortcomings of the method, apart from its inability to cover the important strategic impacts that are not easy to put a monetary value on. As stated above the major sources of uncertainty in connection with a large infrastructure project concern the construction costs (CC) and travel-time-related benefits (Demand), which have great importance for the long-term feasibility of the investment. These uncertainties underlying CBA are examined with Monte Carlo simulation by applying relevant probability distributions for these types of impact [3]. This approach is
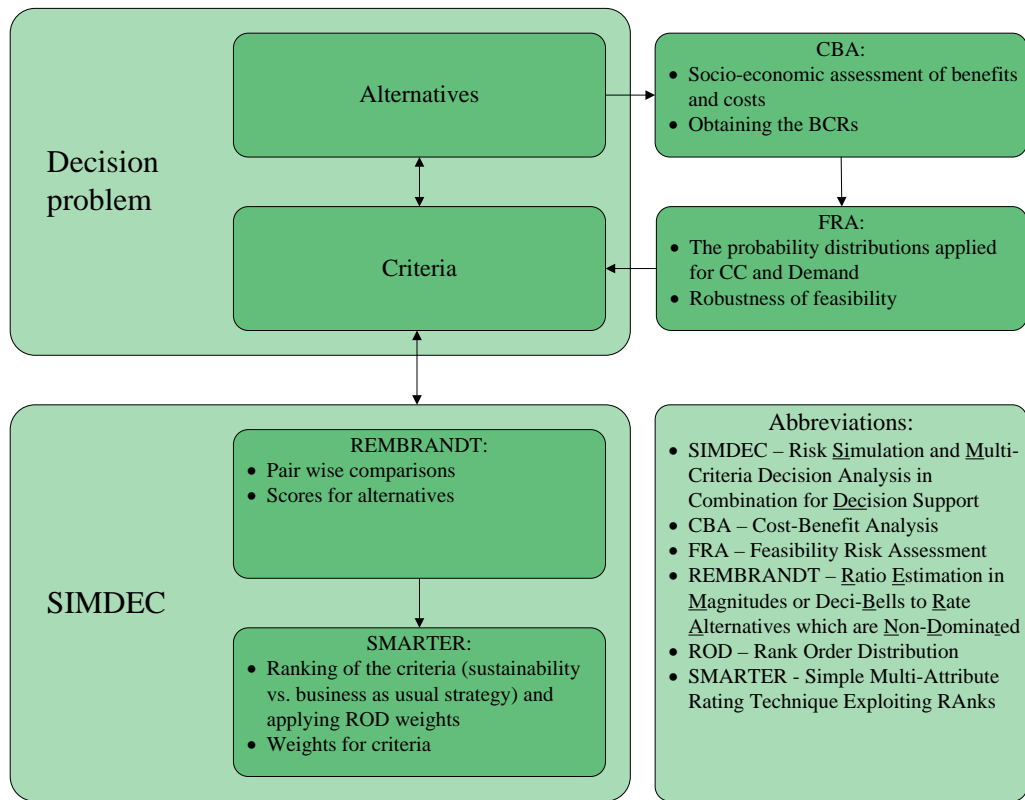
Figure 2 Overview of the DSF-SIMDEC approach for managing sustainable transport development

based upon reference class forecasting technique [4], which employs historical data from similar projects in the past to derive information about the possible outcome of the project being evaluated. The application and simulation of relevant probability distributions provide information that is presented in terms of a certainty graph (CG) for each alternative which shows the probability estimates of achieving at least the benefit-cost rate (BCR) indicated as the CG's argument: $CG(x) = P(BCR \geq x)$. The certainty graph for each alternative is then used to set out and measure a criterion in the MCA representing robustness of feasibility. Examples are given below.

SIMDEC using REMBRANDT, SMARTER and ROD

The SIMDEC approach involves the use of a structured hierarchical technique called REMBRANDT (ratio estimation in magnitudes or deci-Bels to rate alternatives which are non-dominated) for MCA developed at TU Delft [5]. The technique is designed to allow a single decision-maker or a group of decisions-makers to assess a finite number of alternatives under a finite number of criteria. Before the assessment can be carried out, the alternatives have to be characterised by a set of relevant decision criteria. Unlike the CBA, the REMBRANDT technique has been found to be valid and useful for taking all the various indirect and long-term impacts, usually referred to as strategic criteria, into account, while also considering the economic impacts. In SIMDEC, the economic criteria are taken into account by using CBA and feasibility risk assessment, where the resulting certainty graphs represent the overall economic performance of each alternative in terms of robustness of feasibility.

The REMBRANDT technique comprises the following key steps: rating or scoring the alternatives under each criterion, determining the criteria weights and obtaining the overall weighted scores for each alternative. The technique employs pairwise comparisons for assessing the impact of alternatives under each of the criteria. As the alternatives are compared two by two, the preference statement of decision-maker(s) is collected and converted into a numerical value using an intensity scale from 0 to 8, which refers to indifference (0), weak (2), clear (4), strong (6) and very strong (8) preference for one alternative over the other. The relative weights for criteria are determined by prioritizing them based on the SMARTER (simple multi-attribute rating technique exploiting ranks) method [6] applied with rank order distribution (ROD) weights [7], see Table 1, in which criteria are ranked according to their importance and then assigned probability-based weights. The ratings and criteria weights can then be aggregated to obtain the overall weighted scores for all the alternatives; this makes it possible to rank the alternatives according to their attractiveness.

Table 1 Rank order distribution (ROD) weights

Rank	Criteria								
	2	3	4	5	6	7	8	9	10
1	0.69	0.52	0.42	0.35	0.30	0.26	0.23	0.21	0.19
2	0.31	0.33	0.30	0.27	0.24	0.22	0.20	0.18	0.17
3		0.15	0.19	0.19	0.19	0.18	0.17	0.16	0.15
4			0.09	0.13	0.14	0.14	0.14	0.13	0.13
5				0.06	0.09	0.10	0.11	0.11	0.11
6					0.04	0.07	0.08	0.09	0.09
7						0.03	0.05	0.06	0.07
8							0.02	0.04	0.05
9								0.02	0.03
10									0.01

The Rail Baltica case reconsidered in more detail

A decision conference (DC) is a tool that combines technical and societal aspects to deal with complex decision problem situations. The main idea is to get all the stakeholders involved in a decision problem and engage them in a structured debate that can enrich the basis on which a decision can be made. As one of the stakeholders a sustainability or green advocate should be included to highlight the importance of having such factors represented and prioritized in the DC [8], [9]. In the decision conference the stakeholders bring together their different views, which feed into the collective learning process [1].

There are three key elements that interact in a DC: decision analysis, group processes and information technology [6]. The group processes are guided by an impartial facilitator, who steers the group through the whole process and ensures that all the stakeholders get a chance to express their knowledge and opinions. The decision analysis is supported by the decision support software handled by a decision analyst on the spot by applying relevant input information from the DC participants. The decision analysis usually involves a multi-methodological approach

consisting of several different methods suitable for comprehensively assessing the decision problem in hand. The fundamental goal of a decision conference is to create a synthesis from the group process using selected decision analysis methods [1].

One key characteristic of a DC is that the process has no pre-fixed detailed agenda and that it develops based on the input generated at each stage. Conferences can have various layouts and outlines because each is designed to suit the decision problem in hand and the needs of the stakeholders. Each conference may thus proceed differently, but certain stages are typical [8]:

1. Exploration of the issues
2. Construction of the model based on input from stakeholders
3. Exploration of the model
4. Summary of key issues and conclusions

DCs are usually set to last 1-2 days and consist of a number of sessions (depending on the nature of the decision problem) and should be held in 'neutral' surroundings, often an out-of-office location turns out to be a good idea as this can raise the attention of the participants [6]. With a DC built on SIMDEC, one-day sessions have served their purpose in quite a satisfactory way [1].

Description of the case

The case study used to demonstrate SIMDEC concerns the Rail Baltica project, which is aimed at creating a high-speed, European-gauge railway link from Tallinn in Estonia, through Latvia and Lithuania, to Warsaw in Poland. Trains in the Baltic countries currently run on Russian-gauge tracks, which are not compatible with the European-gauge used in Poland and further west. This creates an obstacle to free and fast movement of goods and citizens between Member States of the European Union. Moreover, the missing links and a relatively poor condition of the railway infrastructure in the states at the eastern end of the Baltic Sea lead to the stagnation of rail transport, while road transport is rapidly growing and significantly contributing to the negative environmental consequences of

transport as a whole. Therefore, the Rail Baltica project aims at providing a fast, safe and sustainable rail transport corridor that will improve the social, economic and environmental conditions in the region. A thorough study led to three main options for the construction of the Rail Baltica railway line [10]. The alternatives, referred to as investment packages, are shown in Figure. 3.
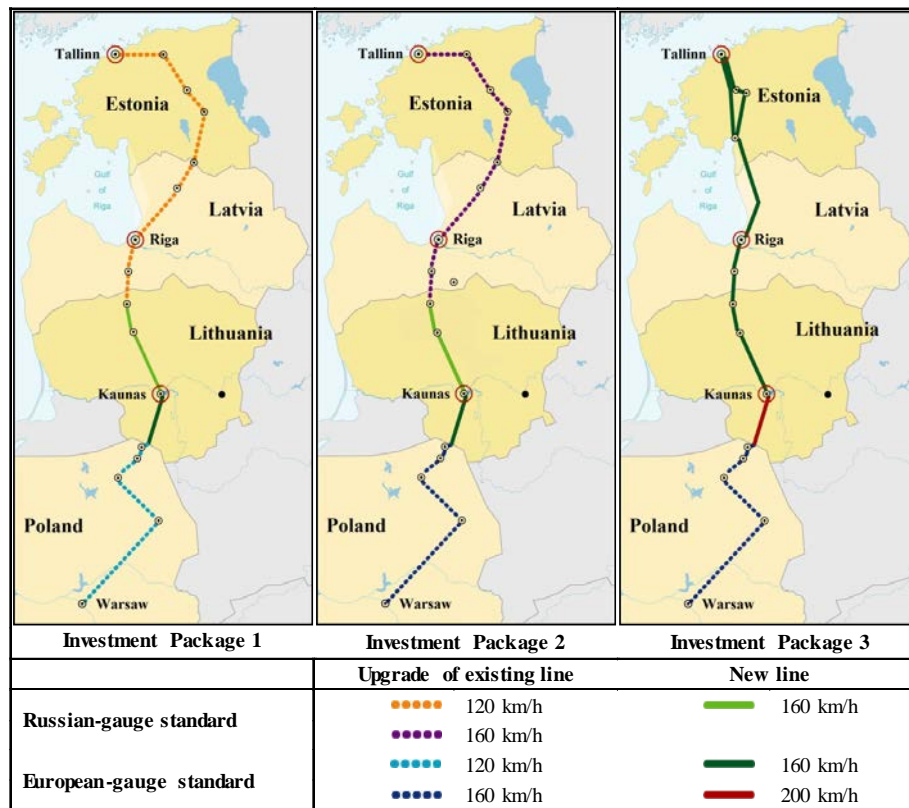

	Investment Package 1	Investment Package 2	Investment Package 3
		Upgrade of existing line	New line
Russian-gauge standard		••••• 120 km/h	—— 160 km/h
		••••• 160 km/h	
European-gauge standard		••••• 120 km/h	—— 160 km/h
		••••• 160 km/h	—— 200 km/h

Figure 3 Investment packages for Rail Baltica adapted from [10]

The three investment packages reflect different levels of improvement in the existing railway corridor in the Baltic States and Poland. Each package has a different combination of new alignments, additional track and upgrades of the old track in the existing alignments, to secure a

defined design speed. Investment Package 1 with a construction cost of EUR 979 million represents the minimal upgrade of the railway network to enable a minimum design speed of 120 km/h from Tallinn to Warsaw. Investment Package 2 with a construction cost of EUR 1,546 million represents a fairly ambitious plan for the upgrade of the railway network to enable a minimum design speed of 160 km/h. Finally, Investment Package 3 with a construction cost of EUR 2,369 million reflects the most ambitious plan for the railway connection in which an electrified European-gauge railway line would be built along the entire corridor from Tallinn to Warsaw. Table 2 describes the investments in each package subdivided in sections.

The assessment of the alternatives in the preliminary study [10] was based solely on monetary impacts because, at that time, the decisive question was whether the investment packages were economically feasible or not for the further examination and analysis. However, besides the monetary impacts, the new infrastructure will have other impacts, which are obviously left out in a purely economic assessment. So, for considering sustainable transport development a more comprehensive assessment is needed, in which all the relevant impacts can be taken into account in a balanced way.

Applying SIMDEC to the Rail Baltica Case with focus on sustainable transport development

The overall goal of the case study has been to demonstrate the potential of SIMDEC to identify not only the most socio-economically sound, but also the most sustainable alternative for the railway connection between Tallinn and Warsaw. To achieve this goal, an abbreviated or truncated version of a decision conference was conducted, in which a group of the best students in the course appraisal methodology at the Technical

Table 2 The three investment packages for the Rail Baltica railway corridor and their specifications

Connection	Section	Description		
		P1	P2	P3
Tallinn-Riga	Tallinn-EE/LV border	No upgrade of the existing line.	Upgrade of the existing line via Tartu to 160 km/h.	Construction of a new line based on European standard gauge via Parnu. Design speed of 160 km/h. Not electrified.
	EE/LV border-Riga	Upgrade of the existing line via Valmiera to 120 km/h.	Upgrade of the existing line via Valmiera to 160 km/h.	Construction of a new line based on European standard gauge from Parnu to Riga. Design speed of 160 km/h. Not electrified.
Riga-Kaunas	Riga-LV/LT border	Upgrade of the existing line via Jelgava to 120 km/h.	Upgrade of the existing line via Jelgava to 160 km/h.	Construction of a new line based on European standard gauge via Jelgava. Design speed of 160 km/h. Electrified.
	LV/LT border-Kaunas	Construction of a new line from Joniskis to Kaunas via Radviliskis. Design speed of 160 km/h.		Construction of a new line based on European standard gauge via Joniskis and Radviliskis. Design speed of 160 km/h. Electrified.
Kaunas-Warsaw	Kaunas-LT/PL border	Construction of a new line based on European standard gauge. Design speed of 160 km/h. Not electrified.		Construction of a new line based on European standard gauge. Design speed of 200 km/h. Electrified.
	LT/PL border-Warsaw	Upgrade of the existing line via Elk to 120 km/h.	Upgrade of the existing line via Elk to 160 km/h.	Upgrade of the existing line via Elk to 160 km/h. Electrified.

University of Denmark was asked to give input for the assessment. Due to the time constraints and the students' limited familiarity with the case, it was not possible to conduct a full decision conference, in which the assessment of the three investment packages using SIMDEC could be carried out. So, the steps of the identification of a set of criteria and ways of measuring them as well as the scoring of the alternatives against the criteria were carried out by the authors of [2], while the students were

asked to weight the criteria. The assessment and the weighting do not necessarily have to be done by the same group of people. The assessment can be carried out by experts in the area of a decision problem, while the weighting of criteria can be done by the various groups of stakeholders, which makes it possible to consider different weight sets when the decision is to be made. Nevertheless, the full potential of a SIMDEC decision support framework will only be seen by using it in an actual planning process and at a real decision conference. This should involve the real stakeholders and/or experts representing different types of knowledge, perspectives and views as they carry out the assessment.

The following set of eight decision criteria (in alphabetical order) was presented as input for the truncated decision conference by the authors of [2] and, after a discussion, approved by the participants as criteria for a comprehensive assessment of the three investment packages:

1. Accessibility and effect on the transport network (C1). This criterion emphasises the impact of the alternatives on accessibility for both the passengers and freight transport.

2. Contribution to the EU green corridors (C2). This criterion emphasises the potential of the alternatives in promoting green corridors. The European concept of "Green Corridors" denotes long-distance freight transport corridors relying on co-modality and advanced technology to accommodate rising traffic volumes while at the same time encouraging environmental sustainability and energy efficiency.

3. Effect on tourism (C3). This criterion emphasises the potential of the alternatives in promoting tourism and attracting tourists to the region.

4. Environmental and ecological effect (C4). This criterion covers the impact of the alternatives on the environment in the region, including issues related to land-use, effects on animals in the region and their habitats, and disturbance to the surrounding area.

5. Health (C5). This criterion considers the impact of the alternatives on the community's health with regard to the emission of noise and air pollutants.

6. Location of companies and logistics centres (C6). This criterion covers the impact of the alternatives on the current location of companies and logistics centres as well as their potential to attract new companies.

7. Regional development (C7). This criterion considers the potential of the alternatives in contributing to the overall development of the region, i.e. the elements that make up society's performance and well-being.

8. Robustness of feasibility (C8). This criterion embraces the overall economic performance of the alternatives by considering the individual certainty graphs stemming from risk analysis.

Feasibility risk assessment and certainty graphs

The first step in SIMDEC is to conduct the conventional CBA resulting in the benefit-cost rate (BCR), which shows the outcome of each alternative per invested monetary unit, and then to apply feasibility risk assessment to produce a set of certainty graphs for the alternatives. The BCR values shown in Table 3 were determined on the basis of European standards and guidelines presented in [11] and [12]. The calculations were done in the CBA-DK model [13]. The key input data and assumptions were based on the final report of the feasibility study on the Rail Baltica case as presented in [10] since the other sources of information in relation to the project were unfortunately unavailable. The data provided in the report was not complete and some of the information had to be interpreted by the authors of [2]. This is why the BCRs obtained differ slightly from the ones given by [10], see [14].

Table 3 The conventional BCR values for the three investment packages

	P1	**P2**	**P3**
BCR	2.92	2.65	2.27

As can be seen from Table 3, all three investment packages present high feasibility, while Investment Package 1 achieves the highest BCR ensuring its selection if this is solely to be based on a conventional CBA. However, as mentioned before, CBA has received criticism for the uncertainties embedded in the resulting point estimate of BCR [3], [15].

The resulting certainty graphs for the three Rail Baltica investment packages are shown in Figure 4, where the BCRs are given on the x-axis and the probability of achieving BCR ≥ 1 is shown on the y-axis. The so-called certainty values (CVs) were derived on the basis of the threshold value (BCR = 1.0) denoted as the minimum value on the x-axis of the graph. The CV for Investment Package 1 was found to be 99%, P2 was found to have a CV of 93%, and P3 a CV of 92%.
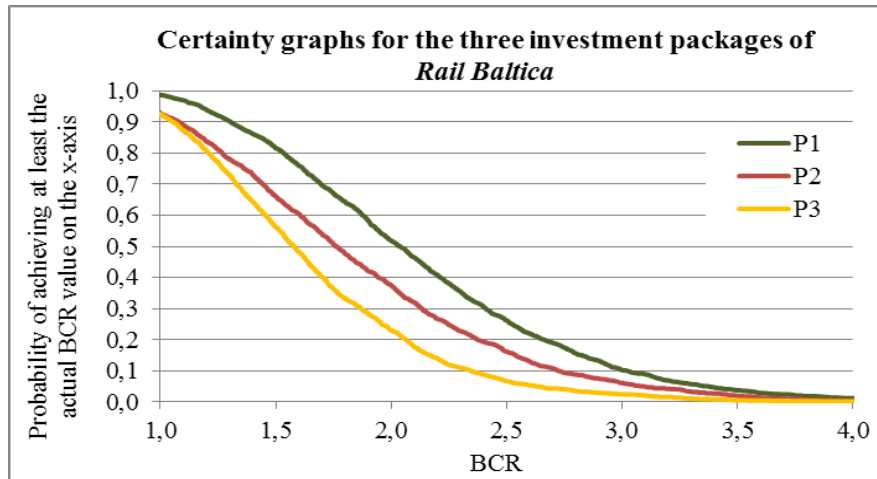

Figure 4 The certainty graphs for the investment packages P1, P2 and P3

The difference between the alternatives under the robustness of feasibility criterion, however, is reflected in the shape in the graphs as can be seen in

Figure 4. To exemplify, the probability of achieving a BCR ≥ 1.5 is 0.84 for P1, 0.68 for P2, and 0.60 for P3. Considering the uncertainty represented by the actual certainty graphs in Figure 4 the socio-economic return on the alternatives is less optimistic than when based on the BCR values shown in Table 3.

Multi-criteria decision analysis and decision onference input

The certainty graphs resulting from feasibility risk assessment were used as the basis for the criterion regarding robustness of feasibility in the final REMBRANDT procedure in SIMDEC. The three investment packages were compared, with numerical values being assigned based on the intensity scale from 0 to 8. The preferences for each alternative under this criterion in terms of numerical values were entered in the matrix shown in Figure 5.

Criterion 1:	Robustness of feasibility			
	P1	P2	P3	Score
P1	0	2	3	3.18
P2	-2	0	1	0.79
P3	-3	-1	0	0.40

Figure 5 The comparison matrix for the criterion regarding robustness of feasibility

For the computation of the REMBRANDT procedures the EcoMobility model [16] was used. The numerical value assigned as the result of the judgment when comparing alternatives two by two was determined based on the verbal scale from 0 to 8, where 0 represents roughly equal value between alternatives, 2 represents the base alternative being slightly more important than the alternative being compared, 4 reflects a clear advantage, 6 reflects strong relative advantage, and 8 reflects very strong relative advantage. Moreover, 1, 3, 5 and 7 can also be used as a compromise between two neighbouring values. When the second alternative being compared is better than the first alternative, the value is assigned with a negative sign. Elements in the diagonal of the matrix are

all necessarily equal to 0. The resulting score of each alternative under the criterion was estimated in terms of the geometric mean [1]. The geometric mean scores for the three alternatives under all eight criteria are shown in Table 4.

Table 4 The scores for alternatives under all the eight criteria, where the scores in bold depict the best rate for an alternative under the particular criterion

The criteria	The scores for each alternative under each of the eight criteria		
	P1	P2	P3
C1	**3.18**	0.79	0.40
C2	0.06	2.00	**8.00**
C3	0.04	2.52	**10.08**
C4	**4.00**	1.00	0.25
C5	0.13	2.00	**4.00**
C6	**2.52**	**2.52**	0.16
C7	0.25	1.00	**4.00**
C8	0.32	1.26	**2.52**

To determine weights for the criteria, the students were asked to prioritize them based on the SMARTER method, in which the criteria are ranked according to their importance. Based on this ranking, the criteria were then assigned ROD weights. The previous Table 1 shows such weights for rankings up to ten criteria.

The basic idea is that the criteria are ranked in a way that prioritizes sustainability viewpoints in accordance with an explicit sustainability strategy, i.e. giving higher importance and accordingly higher weights to the criteria involving "green" aspects. Then, to make a broader analysis possible, criteria are also ranked on the basis of a business-as-usual strategy, in which greater importance is given to the criteria that relate to the economic performance of the alternatives. To do this, the students were divided into two groups, and one group was asked to rank the criteria for the sustainability strategy while the other group was asked to rank the criteria for the business-as-usual strategy. The two specific rankings of criteria are shown in Table 5.

Criteria	Sustainability strategy ranking	Business-as-usual strategy ranking
Accessibility and effect on the transport network	2 (0.20)	4 (0.14)
Contribution to the EU green corridors	6 (0.08)	6 (0.08)
Effect on tourism	7 (0.05)	5 (0.11)
Environmental & ecological effect	1 (0.23)	8 (0.03)
Health	4 (0.14)	7 (0.05)
Location of the companies and logistics centres	3 (0.17)	2 (0.20)
Regional development	5 (0.11)	3 (0.17)
Robustness of feasibility	8 (0.03)	1 (0.23)

All the data on the scores and criteria weights for each alternative in accordance with the REMBRANDT technique were aggregated by a product of the alternative's relative scores under each criterion weighted by the power of criteria weights. The two sets of results in terms of the sustainability strategy versus the business-as-usual strategy are shown in Figure 6. As can be seen, two alternatives, P2 and P3, achieve the highest overall weighted score, depending on which set of criteria weights is used. P2 can be identified as the most sustainable alternative, whereas P3 is best when attention is paid primarily to the economic indicators. However, both sets of results show that Investment Package 1 will never become interesting when the results of the comprehensive assessment are used as decision basis. Although P1 has the best BCR value, its overall performance declines when the strategic issues are considered, that is when the Core Performance (CP) is included in a Wider Performance (WP) examination.
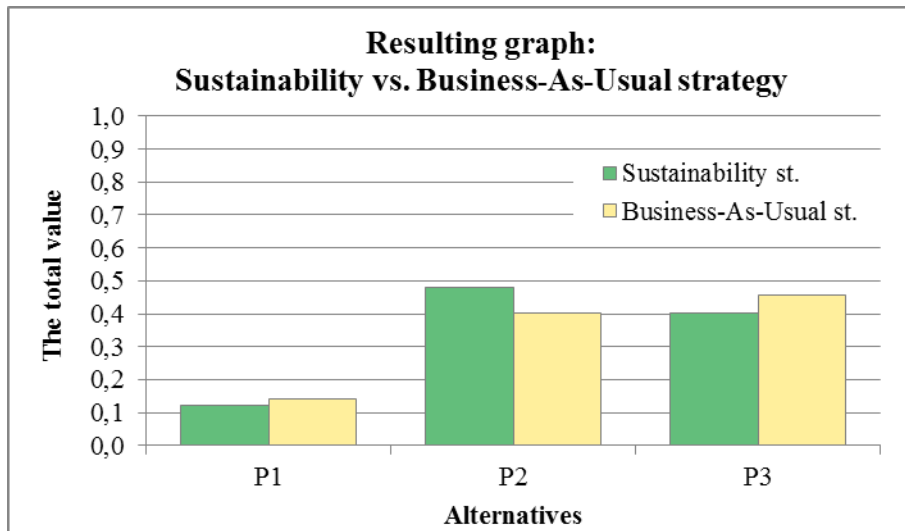
Figure 6 The Rail Baltica case results: With a BAU strategy P3 is the most attractive alternative, whereas P2 is the most attractive alternative when using an SD strategy

Discussion

As can be seen from the case study, the results differ depending on whether CBA or SIMDEC is applied and whether the sustainability or business-as-usual strategy is considered.

Generally SIMDEC makes it possible to incorporate all the various viewpoints that the participants want to be considered in the decision-making process. *Addressing sustainability as an important issue* can be promoted through an SP planning process which can engage the participants in creating a vision of sustainable transport development in relation to the decision problem in hand. This will affect both the process and the assessment modelling and make it possible to see the outcome as a green-vision-based decision.

It is worth noticing that to demonstrate the SIMDEC approach the assessment of the *Rail Baltica* alternatives was conducted on the basis of the combined efforts of the authors of [2] and the students at the truncated decision conference. However, the factual potential of the SIMDEC approach will only be seen when embedded in a full decision conference,

where the identification or recognition of available alternatives, the iterative determination of criteria, the pairwise-comparison scoring of alternatives and the ranking-based weighting of criteria should be done by a real group of experts/stakeholders. With regard for instance to the determination of the criteria relevant for the sustainability strategy to be applied, this will necessitate sound and meticulous preparation of both DC organisers and participants so the most relevant measures for sustainability are applied. This should be based on the use of indicators and other types of information that are relevant for the actual decision problem. So, the listing and ranking of criteria described above, which measure the strength of the three investment packages in fulfilling the sustainability objectives, might be improved by further analysis and examination.

Findings

It is commonly agreed that conventional cost-benefit analysis (CBA) is too narrow a methodological approach for many transport planning problems because transport decision-making often relies on impacts that are not easy to measure in monetary terms. Therefore it has become important to explore project alternatives in a wider context, in which relevant strategic, long-term issues are taken into account. In SIMDEC, seen as a possible method in SP, non-monetary issues are treated together with the criterion of robustness based on feasibility risk assessment which provides a probability-based answer to the question whether an examined alternative is socio-economically feasible or not.

The result of feasibility risk assessment is set out as a certainty graph that in SIMDEC is behind a decision factor measuring socio-economic attractivity. This is but one of a number of factors that have to be included to satisfy the kind of comprehensive assessment that is needed to examine the overall attractivity of an alternative when pursuing the goal of sustainable transport development. In this respect various non-economic strategic criteria of for instance environmental and socio-geographic type should also be part of the criteria set.

Summarising this appendix a major point to be made is that with the growing attention to sustainability in transport planning the approach described makes it possible to *explicitly express the relative 'green attractivity' of each of the alternatives considered.* At the same time, however, each complex planning problem will demand a meticulous effort of the team involved to set out the most suitable decision framework. Needless to say and witnessed by a number of Danish and Swedish cases carried out over the last decade by the Decision Modelling Group at DTU Transport: In SP modelling as with many other things the proof of the pudding is in the eating …

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