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R H Solstrand  
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**ECONOMIC ANALYSIS OF CIVIL  
EMERGENCY EFFORTS - A  
METHODOLOGICAL APPROACH**

HAGEN Janne

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**FORSVARETS FORSKNING SINSTITUTT**  
**Norwegian Defence Research Establishment**  
P O Box 25, N-2007 Kjeller, Norway




**FORSVARETS FORSKNINGSINSTITUTT (FFI)**  
**Norwegian Defence Research Establishment**

P O BOX 25  
 N-2007 KJELLER, NORWAY

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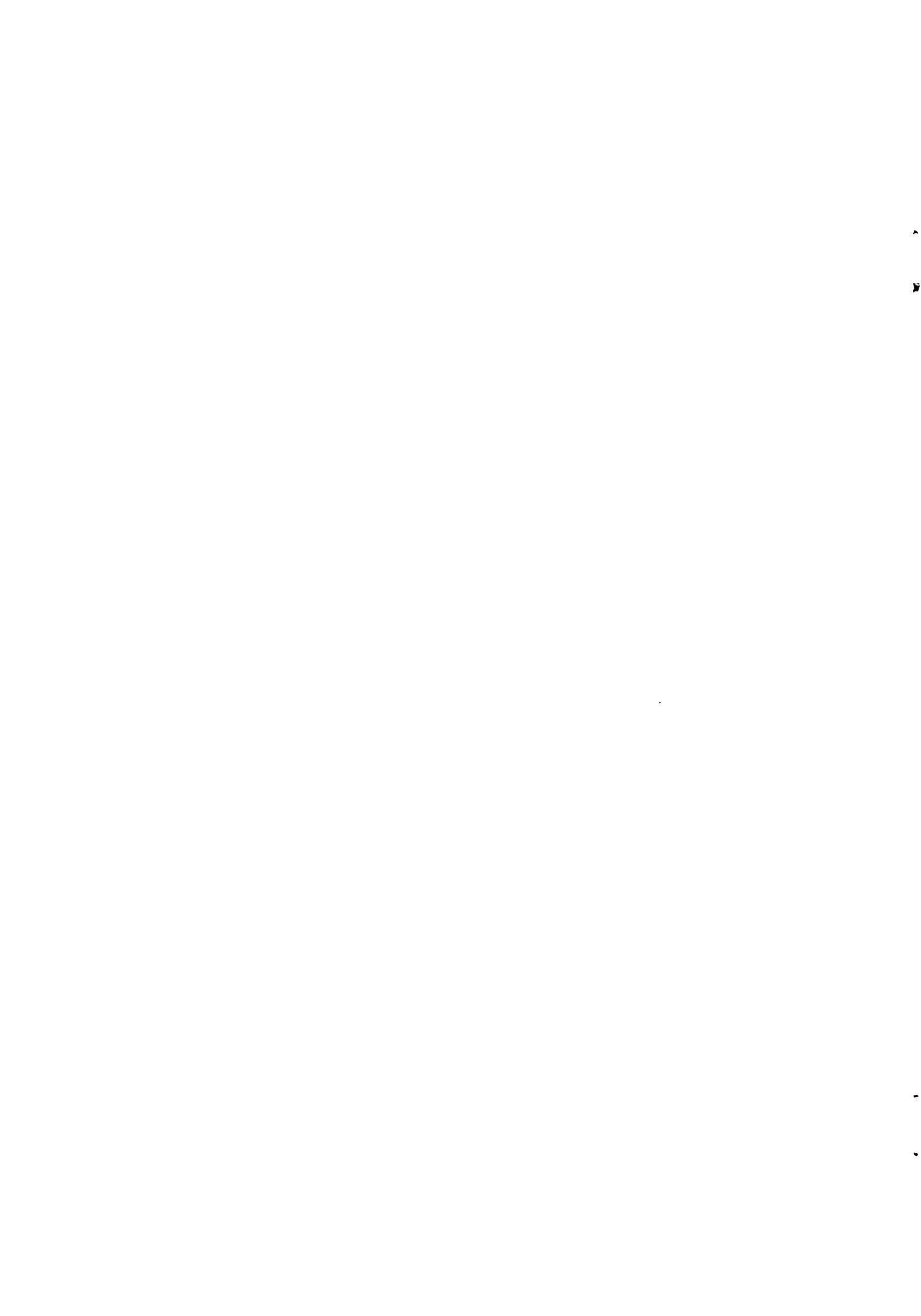
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## **ECONOMIC ANALYSIS OF CIVIL EMERGENCY EFFORTS - A METHODOLOGICAL APPROACH**

Economic Analysis of Civil Emergency Efforts

Paper presented at the 14 ISMOR , the Royal Military College of Science, UK,

September 1st-5th 1997

by Janne Hagen

### **SUMMARY**

"Protection of the Society" (POS) is a joint project between the Directorate for Civil Defence and Emergency Planning and the Norwegian Defence Research Establishment. The purpose of the project is to design and evaluate cost-effective civil emergency efforts. In order to get an overview of the society's need for protection, design of relevant wartime and peacetime scenarios and use of risk analysis have been major activities during the project.

This paper gives an introduction to Civil Emergency Planning and the use of Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA), their areas of application, advantages and limitations. The paper then discusses the relevance of socio-economic profitability as a unit of measure for problems faced in designing a cost-efficient Civil Emergency Planning. Furthermore it presents a general methodological approach that can be followed in cost-benefit/cost-effectiveness analysis of Civil Emergency Planning.

### **1 INTRODUCTION**

The so-called concept of Overall Defence implies that Norway makes use of all available resources in society in order to solve the problems faced in a crisis or war. The Norwegian military defence is based on the civil society's ability to support the forces in war with urgent deliveries of goods and services<sup>1</sup>. The civilian population's welfare together with the society's ability to deliver the required goods and services, have direct implications for the moral of the population and the soldiers in a war, and thus the country's defensive capability at large.

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<sup>1</sup> Nobody has ever been able to calculate the value of this support, but it has been claimed that it contains about 2/3 of the total need for resources. Norway is in an exceptional position compared to other countries, which receive most of the resources via the defence budget (1).





The Overall Defence can be divided into military forces and Civil Emergency Planning. After the end of the cold war, Norwegian military forces have been subject to rethinking. The need for rethinking is also present with respect to Civil Emergency Planning, which is expected to run in parallel with the military forces within the framework of the Overall Defence. In the light of new military and political challenges, budget cuts and requirements for more efficient utilisation of resources, the civil emergency planning faces two kinds of problems:

1. Does Civil Emergency Planning solve the right problems with regard to future threats?
2. How well are the problems solved?

As operations research analysts we aim at finding the right balance between the strategic purposes for Civil Emergency Planning and resources allocated to those purposes. This article comprises a preliminary methodological approach with the aim of analysing Civil Emergency Planning. The two methods, Cost Effectiveness Analysis (CEA) and Cost Benefit Analysis (CBA), are discussed with respect to their applications and their ability to answer the questions mentioned above.

## **2 WHAT IS CIVIL EMERGENCY PLANNING?**

The Second World War demonstrated the importance of a well functioning civil society and public administration. The supply of urgent goods and services to the civilian population, the society and the military forces, turned out to be a painful experience during the war, and led to the establishment of the Directorate for Economic Defence in 1949. In 1970 the Directorate for Civil Defence and Emergency Planning was established under the Ministry of Justice. The Directorate for Economic Defence and the management of Civil Defence were at the same time co-located, but subordinated two different departments. Civil Emergency Planning comprises (1):

- Sector emergency preparedness; preparations connected to production and consumption of miscellaneous goods and services, and sector administration such as health, justice etc
- Administrative emergency preparedness; preparations according to co-ordinated plans, personnel etc
- Co-ordination between all sectors; co-ordination tasks are the responsibility of the Directorate for Civil Defence and Emergency planning, the Ministry of Justice and the county governors.

Civil Emergency Planning is characterised by a high level of complexity and decentralization. In peacetime it is co-ordinated by the Ministry of Justice/the Directorate



for Civil Defence and Emergency Planning and the county governors. All the Ministries contribute to the overall emergency preparedness within their sectors. In case of war or crisis, the government led by the prime minister has the overall responsibility for Civil Emergency Planning. Except for this, the peacetime organisation is fairly similar to the wartime organisation.

Civil Emergency Planning covers a number of efforts within different sectors. Dependent on the external strain, the efforts contribute to different degrees to the overall protection of the society. They cover physical protection, guarding, storages, crisis exercises, and planning activities. The different efforts can be classified as:

- Efforts requiring investments, such as air-raid shelters (long term) and gas masks (short term)
- Efforts requiring operations and maintenance resources, such as planning activities, requiring know-how (long term) and guarding, requiring personnel during a crisis (short term)

### **3 ANALYTICAL APPROACH**

The project "Protection of the Society" (POS) started up in 1994 by the Norwegian Defence Research Establishment (FFI) as a joint project between FFI and the Directorate for Civil Defence and Emergency Planning. The initial purpose of the project was to point out cost-effective efforts, which gave the best protection for the society in peacetime, crisis and war, using a minimal amount of resources. Peacetime threats should be emphasised, but without any reduction in emergency preparedness in war and crisis.

However, the initial purpose of the project had to be revised. The complexity of the problem was at that time too large compared to FFIs knowledge of the subject. Consequently the purpose of the project had to be adjusted to conducting surveys comprising:

- Description of tasks and structure of Civil Emergency Planning (1)
- Analysis of several preventive civil defence efforts, such as air warning, air-raid shelters, evacuation and gas protection (2)
- Description of scenarios regarding relevant peacetime incidents (3)
- Description of military scenarios (4)
- A first broad assessment of key functions of the modern society, such as electric power supply, telecommunication, management and information, transportation etc (5)



• Methodological study of economic analysis of Civil Emergency Efforts (6)

On the basis of these studies the continued work has been focused on developing a methodological approach for economic analysis of Civil Emergency Efforts. Figure 1 presents a general model for this kind of analysis. For two reasons, scenarios are important conditions for the overall analysis of civil emergency efforts. First they represent a time perspective for the analysis carried out, and secondly they help to limit the problem and thus the complexity of the analysis. With a detailed scenario as a basis, we can analyse the consequences of a situation for the military forces, the society and the civilian population in particular. As the purpose of Civil Emergency Planning appears from white papers, the problem seems to be to maximise some utility function (maximising emergency preparedness/protection) with a few constraints: Focus was to be directed towards different peacetime incidents which might appear in the future. Furthermore budget cuts had to be expected in the future without losses of emergency preparedness in a future war.

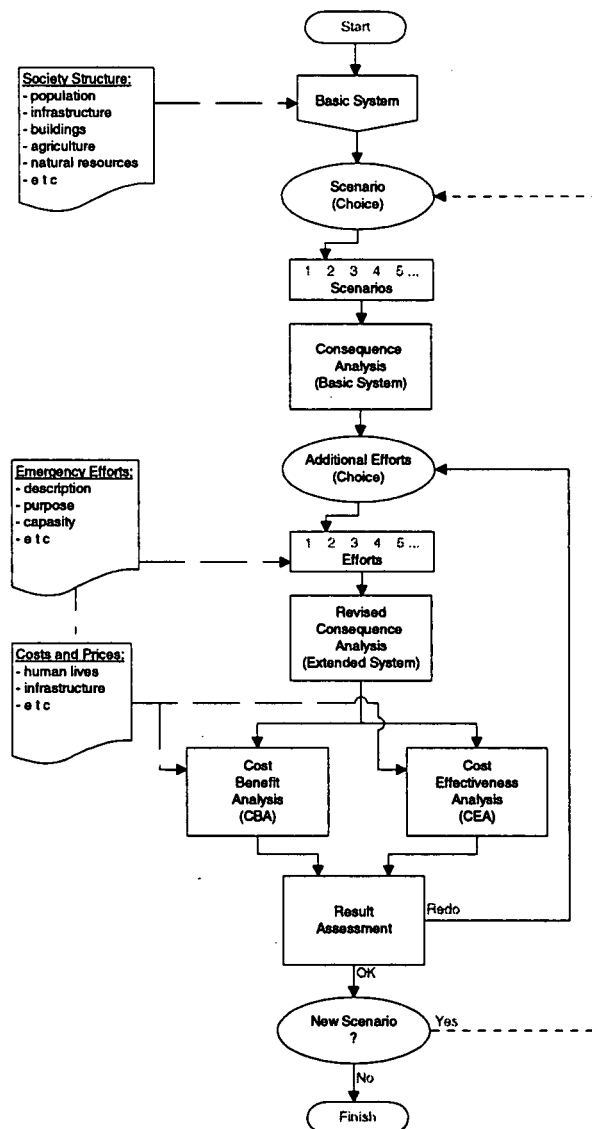
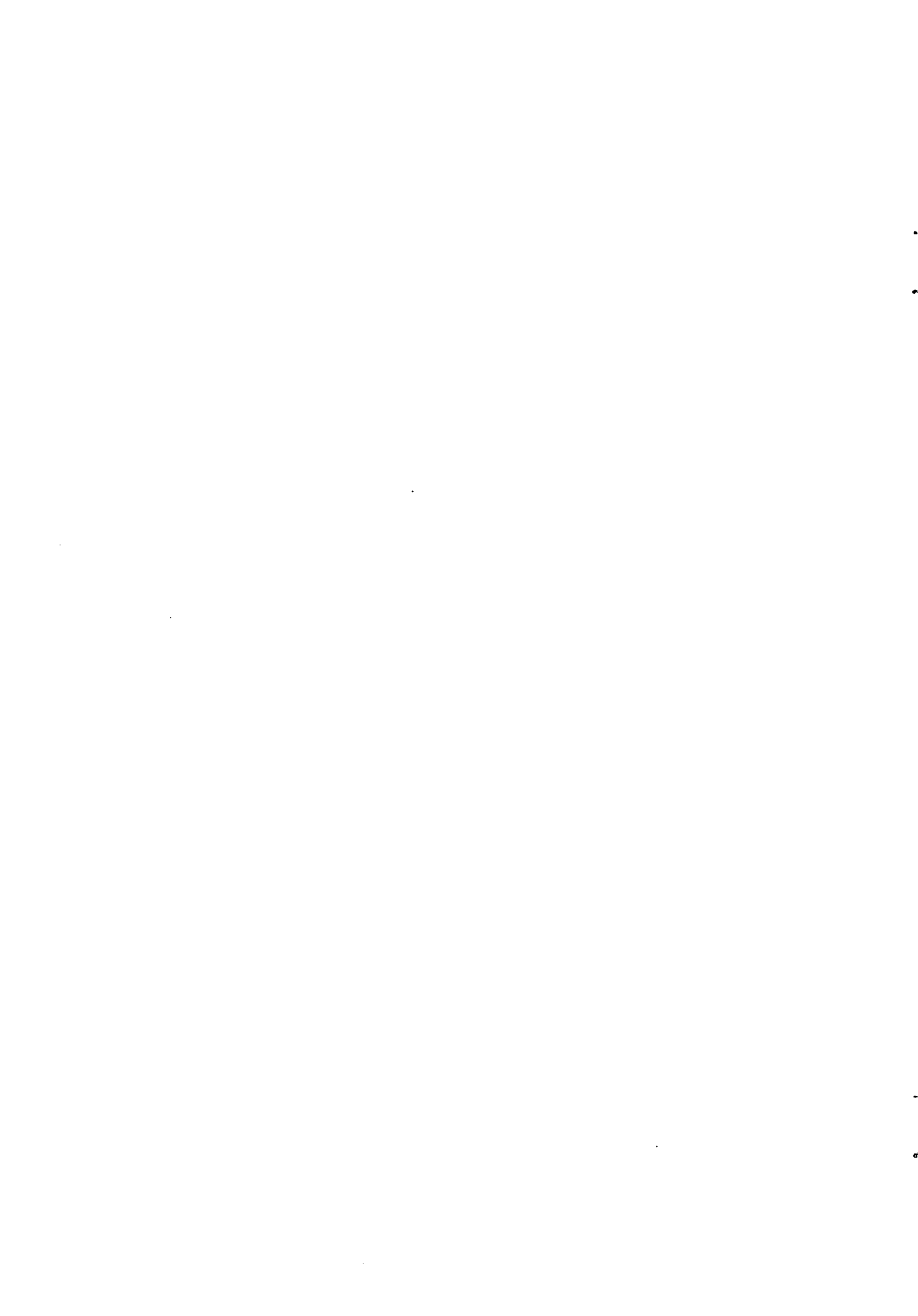


Figure 1 Economic analysis of Civil Emergency Planning - a methodological approach.



The model in figure 1 requires information bases of three categories:

- **Society Structure;** contains information about populations, infrastructure, buildings, agriculture and natural resources a o. This base will play an important role for the consequence analysis. Relevant data can be obtained from the Central Bureau of Statistics.
- **Emergency Efforts;** contains information about different efforts, description of efforts, purpose, capacity and geography etc. Relevant data can be obtained from the Directorate for Civil Defence and Emergency Planning, the Ministriés etc.
- **Costs and Prices;** contains cost information about miscellaneous efforts, economic value of human life, economic value of buildings and other resources etc. Relevant data can be obtained from the Directorate for Civil Defence and Emergency Planning, the different Ministries and other private and public institutions.

The aim is to analyse to what extent different efforts contribute to the reduction of negative consequences for the parties involved. Efforts can be analysed individually as well as collectively. In this respect the vulnerability analysis of the society carried out by the POS-project represents an important foundation in the estimation of effectiveness for the different efforts.

The analysis process described by the model in figure 1 starts with choosing a scenario either from the POS-project (3)(4) or from the scenarios used in the Defence Analysis<sup>2</sup> (7) at FFI. It must be emphasised that detailed scenarios are crucial for the further consequence analysis and the economic calculations.

The consequences of exposing the society to a scenario are then analysed, first on the basis of the fundamental structure and then on the basis of a choice of additional efforts added to the basic structure. If these efforts have a common aim, for instance saving human lives, it will be possible to estimate the effectiveness of the efforts in non-monetary values. An example is the estimation of the number of lives saved as a consequence of an effort, such as an evacuation. Otherwise the effectiveness can be transformed in to monetary values, in other words made comparable. Buildings as well as human lives can be measured in monetary values, and converted to a common measure in terms of socio-economic profitability.

The costs related to the efforts must be calculated, in order to compare the required resources needed with the effectiveness or benefit of efforts. Different approaches of cost estimation can be applied; calculation of Life Cycle Costs (LCC), investment costs or operations and maintenance costs. A lot of conditions comprising depreciation, choice of

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<sup>2</sup> The Norwegian National Defence Analysis.





interest rates, dispersing indirect cost etc must be the same in all cost estimations. Otherwise, the different efforts will not be comparable.

The calculations of costs and effectiveness/benefits are the basis for working out decision making criteria. Examples of decision making criteria are cost-effectiveness ratio, cost-benefit ratio, total costs compared to budget, different effectiveness measures etc. All of these criteria provide important information to the decision-maker.

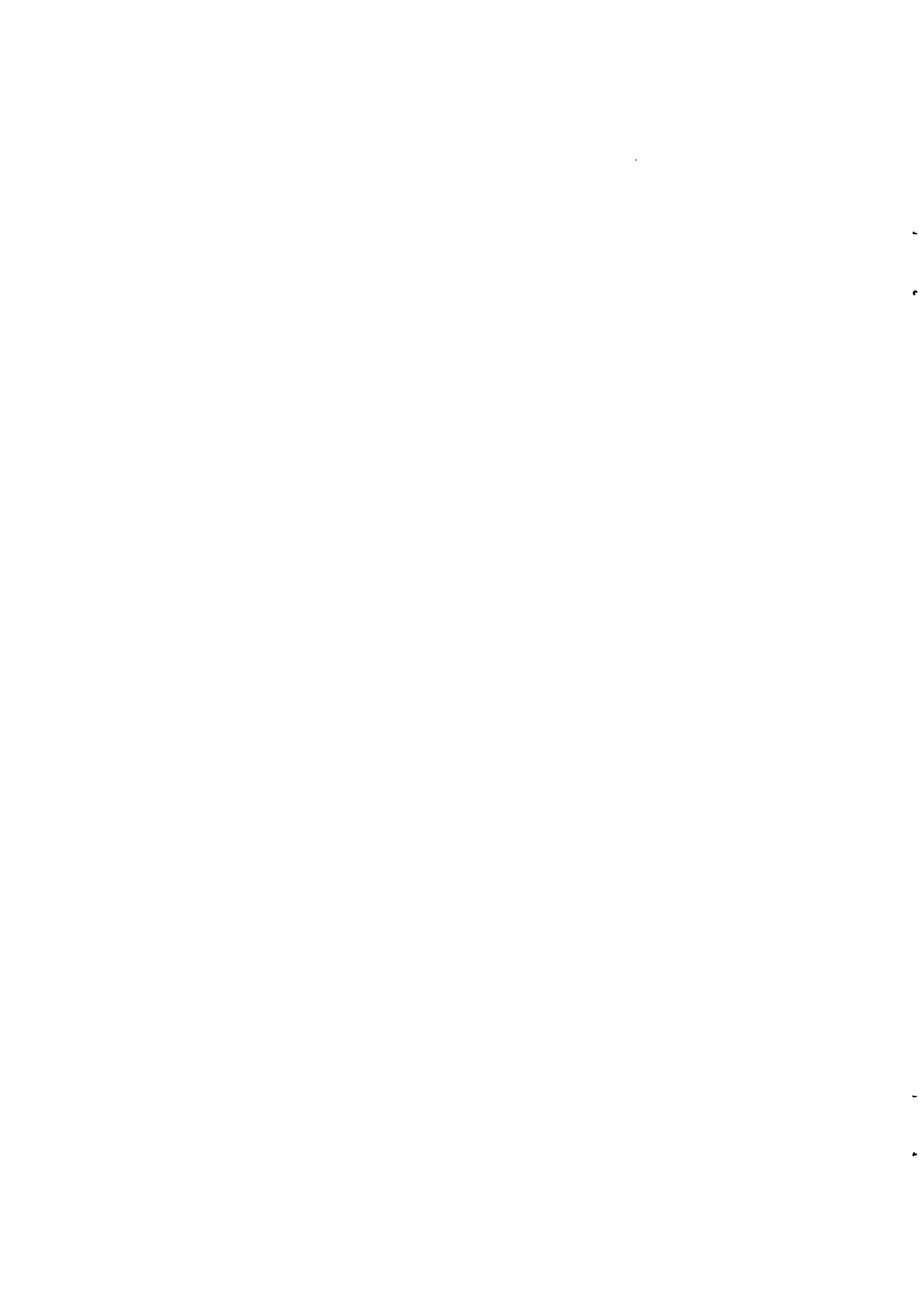
If the result is not satisfactory, the selected efforts might be adjusted or new efforts can be selected to redo the analysis. When the result is satisfactory, new scenarios can be analysed.

#### **4 COST BENEFIT ANALYSIS (CBA) OR COST EFFECTIVENESS ANALYSIS (CEA)**

The model presented in chapter 3 requires use of socio-economic Cost Benefit Analysis (CBA) or Cost Effectiveness Analysis (CEA). The following will discuss these two methods and their sustainability for analysing efforts that give the best protection at the lowest costs.

##### **4.1 CBA - Areas of application, strengths and weaknesses**

Socio-economic Cost Benefit Analysis (CBA) concerns the public sector and is, in many ways, similar to the calculation of profit and loss in the private sector. There are nevertheless essential distinctions between a corporate economic analysis and a socio economic analysis. An study of some years ago (8) can illustrate this distinction: An expansion of the Victoria line in London's subway system would give a shorter travel distance and a reduced travel time for many passengers. However, the result of a shorter travel distance is reduced revenues for the transportation company. The investment cost and operations and maintenance costs exceeded the revenue, and according to corporate economics the project was unprofitable. However, a CBA showed positive profitability because the time saved in travel was valued in monetary terms. The value of time saved exceeded the lost revenue and the accumulated costs according to investment, operations and maintenance. Consequently the project resulted in higher welfare for the society. This demonstrates the fundamental distinction between corporate economic analysis and sosio economic analysis (CBA). In a CBA benefits that are not marketable can be valued in the same way as for instance time saved in travel. These kinds of benefits are known as public goods and within Civil Emergency Planning most efforts can be valuated as public goods. For this reason CBA is a very interesting method when it comes to analysing costs and benefits of civil emergency efforts.



CBA can be used when public funds are distributed among several projects and the method is to a large extent used to evaluate projects within different sectors, such as transportation, health and environment. The cost-benefit ratio of the CBA is an essential tool for the decision-maker:

$$\text{Cost-benefit ratio} = \frac{\text{net benefit}^3}{\text{costs}^4}$$

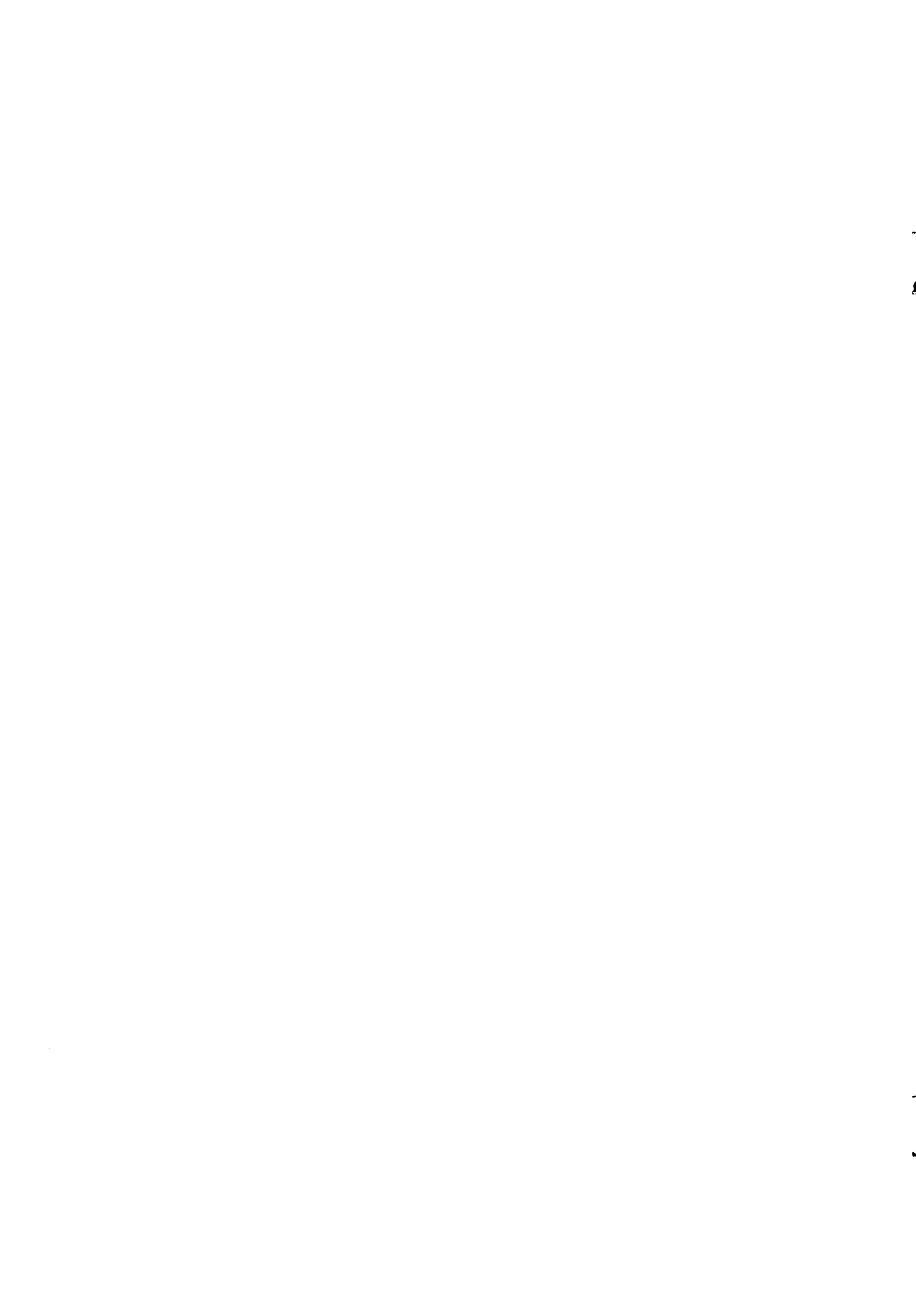
Net benefit and costs are calculated in economic terms and discounted to a common reference year, usually the year of the decision (today). The cost-benefit ratio will exceed 1 if the effort is socio-economic profitable. The higher cost-benefit ratio, the more profitable the effort is. The ratio can further be used to make a ranking of efforts, where the highest ranked effort indicates the best possible use of the budget.

In CBA the calculation of benefit is based upon explicit or "hidden" benefit-functions, which allows us to calculate the benefit and cost in monetary values. The benefit is calculated in the shape of economic profitability. The evaluation of advantages and disadvantages depends on the type of good and the existence of market prices. The goods in a society can be divided into individual goods and public goods. Both kinds of goods are important for the welfare of the society, and should therefore be included in the CBA (9)(10). While individual goods can be sold in a market and measured by market prices, public goods such as air warning must be measured in other ways. The positive benefit of public goods must be estimated through the willingness to pay, and the negative benefit must be estimated through the request for compensation (8). However, the willingness to pay or the request for compensation might not correspond to market prices. In order to find the value of the willingness to pay, we can study the actions of the individuals, for instance by examining their travel expenses in connection with recreational activities. The travel expenses is a measure of the benefit the individuals receive from that kind of activities. Another approach is to do surveys on willingness to pay, for instance Stated Preference Analysis where a population sample must choose among different priced alternatives. Private goods are on the other hand valued through market prices. In CBA market prices must be adjusted with respect to taxes and external effects such as pollution, but there is no need to adjust the willingness to pay or the requirement for compensation in the same way.

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<sup>3</sup> Benefit is an overall concept, which within Civil Emergency Planning covers all advantages (and disadvantages) the members of the society derive from civil emergency efforts. A benefit can be measured in many dimensions. For instance can benefit from a air-raid shelter be measured both in number of human lives saved as well as in monetary terms, where every human life is expressed by a monetary value. The benefit can be positive as well as negative. If the advantages exceed the disadvantages, the net benefit is positive. In the opposite case the benefit is negative.

<sup>4</sup> Costs can be life cycle costs (LCC), investments or operations and maintenance costs. When estimating costs, it is important to decide whether the efforts will be estimated with respect to the cost they represent in peacetime or in a real period of crisis. If we choose to exclude the costs in a real crisis period, we will exclude large costs. If we on the other hand intend to include that kind of costs, we need to know how prices will respond on different kind of crisis.



This is important in CBA because it is the socio-economic profitability that counts, and economic transfers among distinct groups within society means nothing to the overall profitability. However, pollution is a kind of external effect that means extra cost to society and should therefore be included in the CBA.

Within Civil Emergency Planning the valuation of injuries, deaths and accidents is relevant. In order to value these factors, the insurance value of an object or the individual's lifetime income can be suitable measures (11). The society's valuation of avoiding an accident is anyhow at least as large as the costs inflicted on the society if the accident occurs. This can be used as a minimum value of human life.

CBA is applicable in analysis of civil emergency efforts because it makes overall analysis possible, across sectors and among miscellaneous efforts. The overall analysis is possible because the benefit is measured in monetary values. This is the biggest advantage of CBA, besides the fact that CBA also handles public goods. A lot of emergency efforts can be classified as public goods. However, the method has some weaknesses which are worth mentioning. The most significant weaknesses are connected to the calculation of willingness to pay and the time perspective. The difficulties of discounting benefits and costs results in long term consequences not being included in the final benefit and cost. During crisis and war, welfare as we know it in our daily lives, is subordinate to military measures. The government will thus overrule the individual's assessment of alternatives. This is an example of a situation where the use of CBA becomes invalid. However, a modified use of CBA should still be possible.

How a market economy will behave in situations like war, is fundamental for the calculation of benefit and costs. The uncertainty connected with for instance the willingness to pay in wartime scenarios will be so large that use of CBA can hardly be recommended. However, for most peacetime scenarios CBA is applicable.

#### **4.2 Cost Effectiveness Analysis (CEA) - Areas of application, strengths and weaknesses**

Cost Effectiveness Analysis (CEA) arose primarily as an analytic tool for defence and space projects, but is nowadays also a familiar method within environmental analysis (12)(13), transportation studies (14) and health analysis (15). Much of the philosophy and methodology is developed from CBA. There are therefore many similarities between the two methods. The further discussion is concerned with CEA in relation to CBA. First of all it is necessary to define cost-effectiveness:



$$\text{Cost-effectiveness ratio} = \frac{\text{Effectiveness}^5}{\text{costs}^6 - \text{increased incomes}^7}$$

This ratio-model (16) is based on the estimation of effectiveness per monetary unit. The effectiveness of a system is measured in relation to factor inputs (costs). Cost-effectiveness can also be presented as the inverse ratio, that means costs over effectiveness. The different efforts added to a system can be ranked by use of this cost-effectiveness ratio.

There are two methodological approaches in CEA (17). First, there is the fixed cost approach, where the decision criterion is the result of the effectiveness calculations. The aim of this approach is to maximise the effectiveness of a system within a fixed budget. Second, with a fixed effectiveness approach the decision criterion is the result of cost estimations. The effectiveness or performance is fixed, and costs should be minimised. The first approach is common in other analyses carried out at FFI.

Both CEA and CBA are used in the analysis of complex analytical problems, although it has been claimed that CBA is a more advanced method than CEA (18), in particular concerning the estimation of benefits versus effectiveness. However, CEA estimates costs related to effectiveness in a short term perspective and in non-monetary values, while CBA values costs as well as benefits in monetary values, accumulated over a long period of time.

Three conditions have to be satisfied for the use of CEA to analyse cost-effectiveness of complex systems (17):

1. The system properties evaluated must have a common aim; we can for instance compare the effectiveness of gas protection with the effectiveness of air-raid shelters as long as the overall purpose is to protect the civilian population in a region .
2. There must be alternative ways to achieve the aim; air-raid shelter and gas masks are alternative solutions to the problem concerning how to protect civilian population against chemical agents.
3. There must be standardized principles for cost estimation; this means a common approach to estimating the costs of complex systems in economic terms. If the LCC is calculated for air-raid shelters, the LCC also must be calculated for gas protection.

CEA can be used within Civil Emergency Planning in order to study the cost-effectiveness of civil emergency efforts. However, the method requires a common aim in order to compare different efforts. The overall problem, whether Civil Emergency Planning is solving the right problems in relation to future threats, can for this reason hardly be

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<sup>5</sup> A multidimensional function which ends up in one measure, not valued in monetary terms.

<sup>6</sup> Use of investment costs or life cycle costs (LCC) has been discussed.

<sup>7</sup> In the Defence Analysis at FFI the increased incomes are estimated at zero.





answered by using CEA. On the other hand, analysing wartime scenarios requires the use of CEA. In these scenarios there is too much uncertainty about market economy relations to use CBA.

## 5 SOME FINAL OBSERVATIONS

The Norwegian defence budget amounts to about 25 bill NOK<sup>8</sup>, which has been constant even after the end of the cold war. The civil emergency budget amounts to about 0,3 bill kroner<sup>9</sup>. However, in June this year the budget was cut by 25 mill kroner to 0,275 bill kroner. The Norwegian Government expects new political and military challenges in the future, with increased focus on peacetime threats, such as natural disasters, terrorism against society and companies, information warfare against industry and commerce and large flows of refugees to the country because of turbulence in other countries. So far, the questions asked in the introduction are still relevant and unanswered:

1. Does Civil Emergency Planning solve the right problems with regard to future threats?
2. How well are the problems solved?

For peacetime scenarios the CBA can be applied in answering question 1 and 2 above. For wartime scenarios the CEA can be applied for sector analysis and the analysis of efforts with common aims. The continued work at FFI will comprise CEA and sectorial analysis. We will continue the work with developing measures of effectiveness and common principles of cost estimation of efforts. The development of effectiveness measures will represent a challenge in such a huge and complex system as Civil Emergency Planning, and most probably we have to operate with a limited set of effectiveness criteria. A clearly defined and bounded problem will be a condition for success. In a long term perspective the aim will be to develop an analytical tool for civil emergency efforts based on a combination of the principles of CEA and CBA.

Cost estimation has been dealt with only superficially in this article. This does not mean that cost estimation is unimportant or easy. There are a lot of pitfalls, and common principles and assumptions must be the foundation in every cost estimation. Hidden costs in different budgets, in investments as well as in operations, makes the cost estimation work complex. However, we are now in a situation where we have a good starting point for continued studies.

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<sup>8</sup> Norwegian currency unit.

<sup>9</sup> Some of the emergency tasks is included in the Ministries' ordinary budgets, and costs can be hidden in investments or in operations and maintenance. The real budget according to civil emergency planning is probably two times the size of the pure civil emergency budget.



At last, it is tempting to focus on the cuts within the civil emergency budget in relation to future threats, and ask questions 1 and 2 at a higher level:

1. Regarding future threats, are the ambitions of Overall Defence correctly formulated according to the resources assigned to civil emergency planning (0,275 bill kroner) versus the military forces (25 bill kroner)?
2. How well do the military forces and Civil Emergency Planning together solve the problems concerning future threats?

## 6 ACKNOWLEDGEMENTS

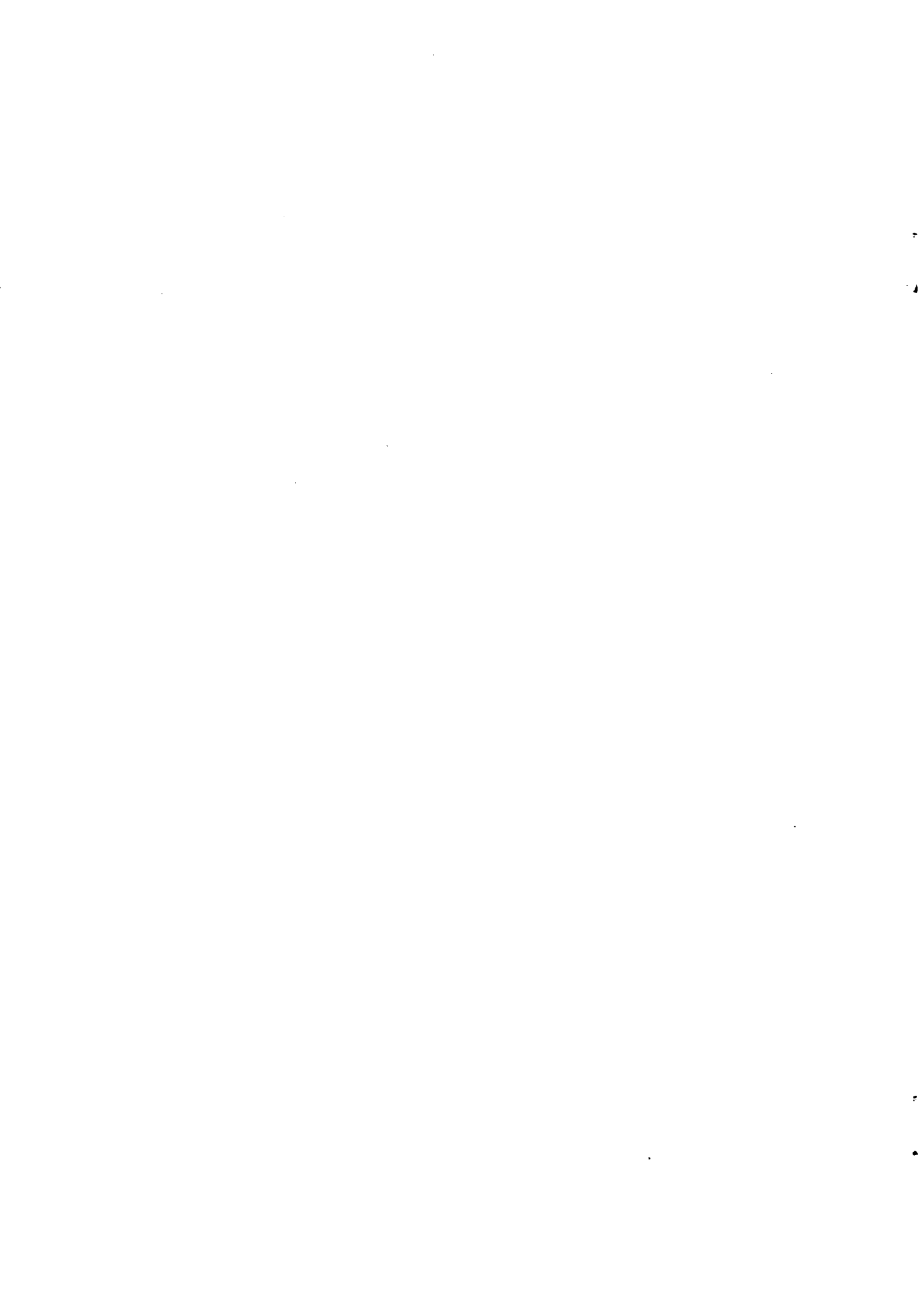
This article is based on the results from a study in methodology in the process of establishing a following-up project of the recently ended POS-project (6). I want to thank my colleague Petter Arnestad, who has been working primarily with CBA. I also want to thank chief scientist Harald Minken at the Institute of Transport Economics and at FFI, chief scientists Ragnvald Solstrand and Bent-Erik Bakken for valuable comments to the report.

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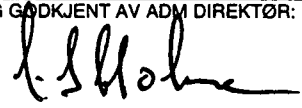


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