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**A REVIEW OF**

**THE DIVISION FOR SYSTEMS ANALYSIS**

**OF THE**

**NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT (FFI)**

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## **SUMMARY AND RECOMMENDATIONS**

### **Introduction**

S1. At the invitation of the Director General of Forsvarets Forskningsinstitut, an international team composed of five experts from Norway, Sweden and the UK have carried out a review of the activities of the Division of Systems Analysis (FFISYS). The names of the team are listed at Annex A of the main report. In the following paragraphs, we summarise our main findings and recommendations using the main headings of the task description (Annex B of the main report) to which we have worked. We would like to pay tribute to the openness and friendly cooperation of everyone we spoke to in the division and to the help we received from the wide range of customers who interrupted their busy schedules to answer our questions.

### **Research Areas and Activities**

S2. The work of FFISYS is clearly highly valued by customers, both in MoD and in the military HQ. Although there were some criticisms, for example of what some described as a tendency sometimes to offer advice which was not based directly on analysis, they were unanimous that FFISYS is a trusted and essential part of the defence organisation. However, FFISYS is organised to carry out substantial studies usually lasting 1-2 years, and there is little involvement with the day-to-day work of the military HQ or the MoD. Several customer representatives indicated that they would involve FFISYS more if they thought the division could respond.

S3. The highest priority activity in the division is to carry out force structure analysis in support of the Defence Studies and the breadth of coverage of the issues involved, although inevitably incomplete, is impressive. We know of no other government operational research (OR) group which is so closely involved in the development of defence policy at this high level. Complementary to this, a number of studies of the cost effectiveness of major future equipment projects have been carried out, notably of the future combat aircraft and the future escort frigate but, not surprisingly, the emphasis on the force structure work appears to have limited the number of equipment decisions in which they are involved.

S4. Certainly, all the work we saw seemed highly relevant to defence, but we noticed some gaps and weaknesses in the coverage. There is no work on the Norwegian or European defence industries in the cost and defence economics group. The relative paucity of work on peace support operations is also a little surprising in view of their increasing importance within the defence policy. This may be due in part to lack of interest on the part of the customer, but we could find no evidence of any FFI strategy for development in this important area.

## **Research Methods and Tools**

S5. Overall, the model structure is not in a very healthy state at present. FFISYS are aware of this and were frank in pointing out weaknesses. The land models, at the tactical level in particular, are old, have been developed in an ad hoc way with inadequate documentation and in some cases all the people who understood them have now left. Consequently they are not often used, yet higher level models still depend on outdated results generated from them. The tendency to build model structures from the bottom up was criticised by some customers, instancing what they saw as the absence of a good top-down model of combined operations. However, we must point out that, because of shortage of staff and increasing demand for studies, under-investment in models has been a common problem in Western OR groups. The staff showed themselves well aware of the range of new tools and techniques now available and steps have been taken to remedy the situation. A small working party on the way ahead is due to report at the end of the year and important practical progress has already been made. We welcome the decision to standardise on two computer languages and to press ahead with the development of a new air combat model, without waiting for negotiations on collaboration with other nations to be complete. We were also very impressed by the innovative work towards including better representation of command and control in combat models, and experimentation with a variety of new techniques.

S6. One area where we have some concern is cost modelling. The primary model used for force structure analysis, KOSTMOD, is a large cumbersome bottom-up model requiring very detailed data and it is very expensive to maintain. We believe that there should be discussions with the military staff aimed at making revision of the data much more automatic. Costs required for equipment cost effectiveness studies are similarly built up from very detailed data supplied by the Materiel Commands. In both cases, the treatment of risk and uncertainty seemed to us cruder than it need be, being based on rather arbitrary judgements, albeit systematically combined. We thought the absence of any top-down parametric cost models a further weakness. These can serve two purposes: first, they enable estimates to be made at a very early stage of projects before detailed estimates are available and, second, they can be used as a rough check on bottom-up estimates which are notoriously liable to underestimation.

S7. It is not entirely clear to us how security policy studies can be integrated into the Defence Analyses and other projects largely based on formal modelling procedures except as a means of developing scenarios, but the work done by security policy staff seems of good quality.

S8. Overall, although there are quite serious weaknesses in the present model structure, we have no doubt that the evolving strategy is sound and will enable a thoroughly up to date model structure to be developed, provided adequate investment is made available. However, we believe that, while responsibility for system analysis

and specification should remain with those tasked to address the problem, programming or coding should be subcontracted either to specialist contractors or to some central group in FFI tasked to fulfil that function for the institute as a whole.

### **Transfer of Research Results**

S9. Formal written reports are the principal way in which FFISYS research results are communicated. We have reviewed a wide selection of these, mainly unclassified and restricted reports, but including a few of higher security classification. They were almost all of a very high quality and very professionally produced. There appear to be no serious impediments to publication in the open literature other than those that security considerations require. There are, of course, many other ways in which research results can be transferred to the customer organisation. The advisory groups associated with each project are an important means by which results are transferred and, perhaps more important, by which the confidence of the customer in the analytical organisation is maintained. Cooperation with the Defence Staff College through the provision of modelling support for war games is also valuable for the transfer of ideas, if not of the results of specific studies, to the military organisation in general and we commend the efforts of FFISYS in that respect.

S10. Finally, we believe that greater involvement in the day-to-day decision making process through opportunities to comment on draft papers would enable more of the division's analytical results to find application.

### **Collaboration**

S11. Although there is a good deal of contact with universities through teaching, particularly by the Security Policy Studies staff, there appears to be relatively little actual collaboration with them or with other organisations within Norway. However, there is a very healthy degree of collaboration and cooperation with other countries. We were shown evidence of the exchange of information and models, collaborative development of models and, in the case of future architectures, an intention to conform to an emerging US standard likely to become accepted internationally. International collaboration on projects has always been difficult to organise and we were not surprised to find little other than with Sweden. Overall, we believe that there is as much international cooperation as it is reasonable to expect and it appears to reflect good value for the resources expended.

### **Personnel**

S12. We were impressed with the quality of the staff that we interviewed. They are young, enthusiastic, of a high intellectual ability, and their academic backgrounds seem for the most part appropriate for the work they are doing. However, we were somewhat surprised to find that cost modelling was carried out almost exclusively by economists and suggest that a better balance is required between economists and engineers with an aptitude for cost analysis.

S13. We were concerned at the high turnover of staff and what seemed to us a shortage of very experienced staff. We accept that this may be in part due to a rather rigid pay and grading structure and suggest this should be relaxed. We are of the view that an effective OR group requires a somewhat different balance between young and experienced staff than does a conventional scientific research organisation. However, we do not believe that this can be achieved by improved pay alone - commercial organisations are always likely to be able to pay more for the best people - and other factors such as career possibilities, allocation of responsibility and a sense of being closely involved in the making of important national decisions as a trusted adviser need to be further encouraged.

S14. The strategy for personnel development within FFISYS appears well developed. We were impressed by what we were told of the training programme, the opportunities for secondment to organisations abroad and for taking further educational qualifications.

### **Organisation**

S15. The internal structure of FFISYS is unusual in consisting of a triumvirate of directors of research, the rest of staff belonging to a general pool from which project teams are formed. This highly flexible arrangement seems to work well for the relatively lengthy projects which are usual in the division at present, but might need to be reconsidered if there were closer involvement with the day-to-day work of the military HQ. Moreover, although the introduction of a leadership triumvirate has made the organisation less dependent on the ability and continued presence of a single individual, it does place a much heavier burden on senior management than would be the case if there were a more conventional management structure. | ?

S16. In general, the structural relationship with customers appears sound, with FFI able to maintain its independence through a funding system which is part budget from the Ministry of Defence (MoD) and part tasking paid for by military customers. In particular, the arrangements by which the MoD has direct access to reports and intermediate results of major studies carried out for military customers is important for the maintenance of an open debate on major issues in the defence organisation as a whole.

### **Specific Recommendations**

S17. Our overall impression of FFISYS is of a well organised division carrying out valuable research for its customers. However, all groups which seek to advise on complex high level defence decisions are bound to have some weaknesses and we have the following principal specific recommendations for the further development of the Systems Analysis Division:

1. FFI, the military HQ and MoD should discuss the best way of increasing the involvement of FFISYS in day-to-day decision making, possibly by providing the opportunity to comment on papers in draft as a matter of routine (paras. 60, 70, 82).

2. FFISYS in negotiation with DG/FFI should agree on the level of investment and organisational measures necessary to maintain the evolving model structure in a well documented and up-to-date state (paras. 34, 75-78, 86).
3. Measures should be taken to reduce the present imbalance between experienced and junior OR staff (para. 82).
4. There should be a thorough review of the relationship between the FFISYS responsibility for the cost model KOSTMOD and the role of the Materiel Commands to provide data, with the aim of making the maintenance and updating of the model more automatic (paras. 26, 88).
5. FFISYS should improve its ability to scrutinise the results of bottom-up cost estimating and to estimate costs by developing parametric models from data on past projects (paras. 29, 72, 88).
6. Quantitative methods less dependent on arbitrary subjective judgements should be developed to deal with uncertainty in cost estimates (paras. 29, 73, 88).
7. More attention should be given to studies of peace support operations and development of suitable models (paras. 24, 85).
8. Security policy studies should be expanded to include studies of the Norwegian defence industry in relation to that of Europe as a whole and to changes in the USA (paras. 31, 89).
9. There should be more emphasis on the systematic integration of security policy studies into the defence analysis and equipment acquisition studies (para. 20).
10. The wider distribution of reports on security policy studies should be considered as should the central collection and recording of informal articles (paras. 22, 69).
11. Further effort should be made to incorporate OR models into computer assisted exercises (CAX) in order to improve the continued professional training of commanders (paras. 41, 87).
12. FFISYS should consider more involvement by universities, civil OR groups and consultancy firms in specialised areas such as 'soft' methods, cost estimating and risk analysis (paras. 37, 38, 90).



## **INTRODUCTION**

1. The Director General of the Forsvarets Forskningsanstalt (FOA), Stockholm, had initiated regular reviews of his divisions by external review groups and approached the Director General, Forsvarets Forskningsinstitut (FFI) with a proposal that it might be of advantage to commission a single group to review both their defence analysis divisions in parallel. Following agreement between FOA and FFI, a group of five independent external experts was formed, consisting of two Swedish members, two Norwegian members with a chairman/rapporteur from a third country (UK). A list of the members of the group is given at Annex A.

2. The group were asked to present their findings and recommendations for the two divisions in separate reports. A single task description for the review was agreed and is set out at Annex B. The review group was asked not to attempt any comparison of the two organisations in terms of the relative quality of their contributions. However, there are major differences in the way the Swedish and Norwegian groups are organised and in their relationships with customers, and the group have therefore thought it appropriate to include at Annex C a brief summary of these.

3. The present report has been discussed in draft by all members of the review group and represents our agreed view.

## **METHOD OF WORKING**

4. As a prelude to the main field work, the team had an interview with the Chief of the Defence (CHoD), General Solli, at his military headquarters on 19 August. Mr Nils Holme, Director General of FFI and Dr Ragnvald Solstrand, Avdelingsjef FFISYS, also contributed to the discussion. Afterwards, the team visited FFI at Kjeller where they received presentations from Dr Solstrand and his two fellow Directors of Research in FFISYS, Mr Reidar Skaug and Dr Bent Erik Bakken. Following this visit, the team designed a questionnaire which was sent to FFISYS in September and a composite reply was received by the team in early October.

5. The main field work consisted of interviews primarily with FFISYS staff but also with representatives of customer organisations, namely the Plans and Policy Staff, the Army, Air Force, Naval Staffs and MoD. These discussions took place on 20-22 October and a second visit to FFISYS was made on 12/13 November to clarify areas of uncertainty. In addition, FFISYS made available to the review group a selection of reports on studies carried out over the past three or four years. Copies of these were made available at FOA as well as at FFI, so that members of the review group living locally could pay additional visits to read them. The fact that most of these were written in Norwegian, apart from abstracts, unfortunately limited the access of the English member of the team.

6. In summary, the review is based primarily on interviews with FFISYS staff supplemented by presentations and discussions with senior management, replies to a questionnaire, interviews with customer representatives and a review of a selection of the reports published.

### **FFI SYS AND ITS FORMAL RELATIONSHIPS - AN OVERVIEW**

7. FFISYS must be evaluated with reference to FFI's general objectives and organisational structure, as expressed in FFI's by-laws (given by the Government as a "Kgl.res:" on December 9, 1994). From this we judge the primary objectives of FFI to be limited to research and development (R&D) of particular relevance for the Norwegian defence, including both political and military aspects. Of particular importance for FFISYS is the specially mentioned objective for FFI to keep themselves informed on scientific and military technological developments that may influence security policy or defence planning, to take the necessary initiatives to inform the political and military leadership of such developments and to contribute to industrial and technological development in Norway. One of the primary tasks mentioned, also of particular importance for FFISYS, is that FFI shall be informed of the current plans for defence structure and major procurements of material, and assist in the implementation of such plans and procurements, making the best use of the professional capabilities of the institute. Further, it is stated that the institute shall cooperate with other R&D institutes, nationally and internationally, insofar as this does not interfere with security aspects. In our response to the different items in the task description (Annex B), we have kept this understanding of the primary objectives in mind.

8. FFISYS is the systems analysis division of FFI, the Norwegian Defence Research Establishment, an agency of the Ministry of Defence. The work of FFISYS is formally supervised by several external boards. Of these, the most senior is the Defence Research Policy Board (Forsvarets Forskningspolitiske raad), chaired by the Chief of the Defence (CHoD), which meets four times a year and reviews priorities for all defence research related activities including those carried out intramurally by FFI. The recommendations of this board, although advisory to MoD and to FFI, are normally followed. There are two other groups with important responsibilities for FFI work: the FFI Management Board (Styret), currently chaired by the previous Chief of Defence and including a number of independent members, and the Proposal Review Group. The Proposal Review Group (Forskningssjefenes Raad/utvidet), chaired by the Chief of the Plans and Policy Staff, reviews project proposals, termination reports and the reorientation of ongoing projects, while the Defence Research Policy Board values the activities of FFI in a broader perspective.

9. Until about 6 years ago, 90% of FFISYS funds were under its own control but this is no longer the case. The funds for FFI as a whole now consist of two parts: a basic budget amounting to about 45% of the total negotiated with the Defence Research Policy Board, who recommend priorities for the underlying long term programme, and directly tasked individual projects amounting in total to 55%. Of these, all except about 5%, are defence-related with work for the Materiel Commands

dominating. However, for FFISYS, the proportions were very much more variable than for the rest of FFI. Work for the Materiel Commands is very much concerned with the procurement of a particular project from industry starting from providing background for the writing of specifications and at a later stage (say, 5 years) supporting the development by advice directly to industry. All such work is paid for by the commands.

10. The setting up, conduct and closure of a project is a highly formal process with the relationship to the customer closely defined. Projects may be initiated by FFI or at the request of the customer. In either case, a project proposal results only after thorough discussions between FFI and the customer. At the proposal stage, there has to be agreement on the total cost and on any division of cost between the customer and FFI. While the customer will invariably pay for the analysis, the cost of developing methodology may be split between the customer and FFI. All proposals for new projects must be submitted for approval to the Proposal Review Group and for each project an advisory group (prosjektraad) is set up for the duration of the project including customer representatives and one of the Directors of Research. The project leader is also present at meetings of the Project Advisory Group. Most projects come in close to the agreed time and resources but some work may be carried over into a following project. A report on how long a project has taken and what was achieved compared with the plan is submitted to the Project Review Group and a summary for all projects is submitted annually to the Defence Research Policy Board.

## **ORGANISATION AND MODE OF WORKING**

11. FFISYS is headed by Dr R H Solstrand, supported by two other Directors of Research. Projects are grouped under the three directors so that each covers a broad range of projects and has a roughly equal workload. The staff totals 66 at present, consisting of: 44 graduate scientists, 3 scientific assistants, 7 military officers, 6 national servicemen and 6 administrative support staff. The organisation is essentially project-based with teams being formed for each project from the total available staff under a project leader who is usually dedicated full time to the one project. Other team members may also be contributing to other projects.

12. The typical duration of projects is 2-3 years and in the last 5 years no formally approved project has had a duration of less than one year. In addition to these, FFISYS is sometimes asked to carry out ad hoc studies which may have a duration of a few weeks or a few months, but these amount to less than 5% of the total workload. There is considerable variation in the total effort allocated to projects. Duration usually varies between 5 and 15 man-years and may involve 2-5 scientists. However, the duration of tri-service defence analysis studies may be 2-3 times larger. Almost 35% of the graduate staff in the FFISYS have greater than 7 years experience of operational research and a further 28% have between 3 and 7 years experience.

13. Studies of the cost-effectiveness of alternative equipment options and force structure analysis amount to about 70% of the activity of the division. Security policy studies constitute another 10-15% of the total and a further 10% is accounted for by model development and basic research. A small amount of work on logistics

has recently started but no work is currently carried out on alternative tactics or on deployment, albeit that some work on the former topic is tentatively planned.

14. In order to recruit staff, vacant positions are advertised in newspapers and journals. A group of 3-4 people (mainly scientists) is selected from the staff at FFISYS. The task of this group is to assess the qualifications of the candidates and to arrange interviews with those considered best qualified. Based on this, a ranking of the candidates is prepared, and presented to the Head of the Division. He then writes his recommendation to a five-member Employment Committee at FFI that evaluates the recommendations and formally employs one of the candidates. The majority of recruitment is straight from university and some new recruits have prior experience of FFISYS through attachment during their national service.

15. Once recruited, training in operational research during the first 5 years of employment starts with an introductory programme carried out during the first 6 months of employment. Brief introductions to various aspects of OR, economics and political science are given and excursions made to MoD, to military HQ's and to naval, air force and army bases for demonstration of defence equipment and for briefings on missions. After 3-5 years of employment, employees can be given the opportunity to spend up to a year at a foreign university or research institution. Also, employees are encouraged to follow courses/seminars at universities, etc., and are allowed to use five hours of their working week for this purpose, subject to their project leaders' approval and as part of a plan for training in a specific field.

16. The normal process of professional development for scientific personnel is first to achieve thorough understanding of one specific problem area, then to broaden the scope by moving to another area or to problems on a higher level. In this process, individual strengths and preferences are clarified and taken into account by the division management when composing new project teams and offering possibilities for additional education.

17. The main consideration when allocating personnel to studies is the availability of personnel with the most appropriate combination of academic and personal qualifications. However, also taken into account as much as possible are the individual employees' preferences and wishes as communicated during everyday work and annual appraisal interviews.

#### **INTERVIEWS WITH FFISYS STAFF**

18. Since FFISYS is organised on a project basis without hierarchical sub-division into lower level groups, we have divided their work into:

- 1) security policy Studies
- 2) Cost Analysis and Defence Economics
- 3) Present Model Structure

- 4) Future Models
- 5) Force Structure Analysis and Equipment Studies

We interviewed staff engaged in each of these areas of work (list at Annex D) and in the following paragraphs summarise what we learned.

### Security Policy

19. Although its members are nominally available for any study, the scientists working in the security area are a recognisably coherent group. The group activity started in the 1960's and after initial successes, declined in the 1970's and early 1980's to only two scientists. However, from the mid-1980's it expanded until now it consists of 7 scientists (5 political scientists, 1 historian and one scientist with a speciality in the Russian language). Two military officers bring the total to nine. In the 1960's studies were mainly strategic and included arms control and nuclear policy. In the 1970's a series of international relations related studies were carried out (e.g. on oil and the coastguard) but little attempt was made to integrate these with the rest of the work of the division. However, since then, efforts have been made to integrate security policy studies into the mainstream work of the division.

20. The group contributed work on future planning scenarios for the recurring series of defence analyses starting with Defence Analysis 91. For Defence Analysis 96, this process was taken one step further with the integration of political scientists into the project in order to develop scenarios from a broad study of international relations. However, there remains a need for political studies in an international setting unrelated to the defence analysis work and a wide range of studies have been carried out. Two such projects concern the implementation of peace agreements, based on case studies of Bosnia and the Palestine problem, and on possible future developments in Russia. More generally, a theoretical approach to establishing the relationship between institutions and "order" in international politics is in progress.

21. We were told that the duration of security policy studies are generally shorter than that of OR studies; typically 1 1/2 - 2 years and with a total effort of 2-3 man years with perhaps up to 5 staff taking some part. The project leader would usually be wholly committed but draw on part-time help from others and the group usually carried out no more than three projects at a time. In addition the group buys 2-3 months effort per year from external consultants.

22. The distribution of FFISYS reports on security policy is decided by the Director General on advice from the authors or the project team. In response to a suggestion that the distribution of reports seemed unduly limited, FFISYS replied that this gave an incomplete picture - staff also contributed articles to periodicals (including those with external review) and newspapers, were involved in writing books, contributing to anthologies and attended seminars. Moreover, FFISYS staff also take part in study groups run by MoD and the Ministry of Foreign Affairs, providing supporting analysis.

23. Security policy studies staff maintain close contact with universities. Two or three people are supervising student theses, where these fit in with the FFISYS studies programme. They also carry out a good deal of teaching and assist with war-gaming at the Defence Staff College. Overall, the external teaching effort amounts to a total of between 2 and 3 weeks of effort per year, excluding preparation time.

24. Work on peace support operations (PSO) and on crisis management started in the security policy studies group with the organisation of national seminars. The idea was that this work should gradually become part of the OA studies framework but although some insights were incorporated into Defence Analysis 96 this has not yet been achieved.

### **Cost Analysis and Defence Economics**

25. About six permanent staff are currently involved in work related to cost analysis and defence economics. All are economists and there are in addition two graduates doing their national service at FFI.

26. The main emphasis in recent years has been on Defence Analysis 96 and three staff have been involved, mainly in estimating the costs of future force structures. For this work a model called KOSTMOD was used. This is an accounting model developed in-house in its present form for defence analysis in the early '90's and based on ideas and algorithms originating in the '70's. It consists of three separate data bases for Army, Air Force and Navy, and aggregates detailed basic data obtained from various sources to output the total cost of a proposed force structure for each of the next 10-15 years. Of the 1000 or so categories of equipment systems in each of the Services, less than 100 have been shown to account for about 90% of total value. The remaining 10% have been lumped into a few general categories. In this way the model has been made more tractable with about 100 categories and all costs included. As well as the investment and running cost of equipment, all the costs associated with military units and HQ's are included and account is taken of the age distribution of stock, life expectancy, loss rate and cost escalation factors. About 4-5 persons are currently familiar with the model which takes about a week to prepare for running. FFI is the main user of the model and responsible for the database. It is also used within the Army Staff but neither the Air Force or the Navy are comfortable with it and so ask FFISYS to operate it for them. The main weakness of the model is that it requires everything to be specified in complete detail, so is not very suitable for estimating running costs. Consequently, it is very expensive to maintain. Major updates to the data base are carried out every 3-4 years, requiring 2 man-years of effort at FFISYS and 2 man years on the part of each of the three Services. A new version of the model is currently being developed by an external consultant.

27. In Defence Analysis 96, sensitivity tests were carried out to establish the effect of uncertainties in the data on estimated total costs. During the run up to Defence Analysis 2000, it is intended to improve the model particularly in respect of the representation of operating costs in peacetime and the way these are related to the force structure.

28. In addition to the work on force structures, life cycle cost (LCC) estimates are made for equipment system cost-effectiveness studies (e.g. future combat aircraft, future frigate). The uncertainty in the total cost of the equipment is calculated from data on individual components which are originally qualitative but are then converted to uncertainty percentages. These are assumed to represent the outer limits of a skew triangular distributions which are then combined using standard statistics. There are frequent differences of opinion between the military staffs and FFISYS on cost estimates and this may be partly due to the fact that FFISYS make allowance for the cost escalation between generations of equipment fundamental to defence procurement.

29. All of the models are essentially of the bottom-up aggregating type and there are no top-down parametric models which can be used when detailed cost data for components are not available.

30. Members of the group are currently involved in a feasibility study for a cost accounting system for the armed services. This is aimed at giving managers more freedom to spend to achieve their targets while preserving accountability.

31. Finally, a small project (20% of one person) has been carried out on the future of the Russian economy. However, although one study of the Russian defence industry has been carried out, there have been no studies of the Norwegian or European defence industries.

### **Present Model Structure**

32. The model structures for air, sea and land combat were described as being at the technical, tactical and operational levels, in ascending order of abstraction, with each level depending to some degree on the results from the level below.

33. Models have been developed over the years in an ad hoc way to cover specific project needs as they arose. Only recently have model compatibility and interaction been considered. The most complete model structure is that for air combat but even here documentation is scarce and some models (eg SILKA) are now very old.

34. The land model structure is to a considerable degree obsolete with in some cases no one left at FFI who understands the models and almost no reliable documentation available, the models having been continuously modified to cope with a succession of projects. In particular, we were told that the low-level models (PABST and DYNACOM) could no longer be supported but higher-level models still use old results from them. The higher-level models (Minos, DIVMOD, TRIAMOS) all have incomplete representations of air operations and for force structure studies are most frequently used in war gaming mode.

35. The model structure for naval operations has, like those for land and air operations, evolved in an ad hoc way with some models imported from other countries (e.g. OSCAR, EWSING and MSM from the UK and Helo from the Netherlands). At

the higher level, the Sea Lines of Communications Model (SLOC) is used for naval force structure work and is a large stochastic discrete event simulation with advanced automatic decision modules requiring input data at a moderate level of aggregation from lower-level models. It evaluates the convoying military and civilian supplies from Southern to Northern Norway. SLOC is complemented by RASIM, a deterministic spreadsheet model in three independent parts which evaluates enemy landings in Norwegian fjords and attacks on enemy sea lines of communication. It depends on aggregated data from the now obsolete ASIM and lower-level models.

36. As well as for force structure studies, SLOC/RASIM have been used for studies of the numbers of future frigates required while OSCAR, a large object-oriented stochastic simulation of a single convoy subject to air, surface and subsurface threats has been used to evaluate the range and characteristics of the sensors required by the future frigate. All of these models have recognised deficiencies and do not very conveniently interface with each other.

37. FFISYS have traditionally concentrated their attention on so-called 'hard' models; that is to say, models such as simulations and spreadsheets which use quantitative input data and produce quantitative results. Recently some qualitative 'soft' techniques have been applied in areas other than combat modelling. For example, 'morphology', a method of assessing the dimensions of a problem, has been used a little for security policy studies and, in the economics field, causal matrices, a technique apparently similar to the non-mathematical parts of Saaty's AHP method, have been used together with brainstorming.

38. System dynamics is a methodology which lies somewhere in between 'soft' and 'hard' methods in that it can be useful simply as a conceptual tool to understand causal loop diagrams, but can also be computer programmed to produce a quantitative output. As a conceptual tool, the method can be used for a wide range of problems including, for example, security policy studies. It is not used in that particular area at present but one of the Directors of Research (Bent Erik Bakken) proposes to develop a model as a demonstrator.

39. There has in recent years been an increase in the priority accorded to the modelling of the command and control process. A model called STASIM (Functional Structure of the Staff Simulator) has been constructed to evaluate various systems in terms of their speed and robustness in the face of attack. It is currently being used to develop a command and control structure for an army division (DIVISION 2000), following a previous analysis of an Air Force command and control structure. A variety of other models are currently available but they are only loosely connected and stop short of evaluation of the effect of command and control on the outcome of combat.

40. Wargames are not much used by FFISYS as a primary means of carrying out studies because they are slow and it is difficult to make analysis based on them objective. However, the construction of a new simulation model will usually be preceded by carrying out perhaps three or four open wargames, using maps and supported by calculation of losses in the successive engagements involved, in order to decide the factors to be included in the model. Each such game is likely to take 2-3



days and represent about 2 weeks of combat time. Then, following construction of the model, it would be checked by making it imitate the wargames. Also, attempts to introduce into the staff college wargames supported by FFISYS models have recently been very successful.

41. Less successful have been recent attempts to improve the large command training games, known as computer assisted exercises (CAX), by supporting them with models such as Minos, air campaign models, the airfield damage model and SLOC. Introduction of these models achieved little in practice, principally because the present purpose of the games is to train command staff in procedures. What this failure demonstrated is that there are currently no facilities for the continued training of high level military staff in their command roles.

### **Future Models**

42. The deficiencies of the current modelling structure are well recognised by FFISYS management and a working group on future strategy is due to report by the end of the year. However, some decisions are already being implemented. It has been decided to standardise on two object-oriented languages for the future: Smalltalk and Modsim. A new tactical level air combat model is being developed to replace SILKA. It is hoped that this will become a collaborative project possibly with Germany and the Netherlands, perhaps with the UK (CDA), but these negotiations have not been allowed to delay development in FFISYS. Also there is a well developed plan to construct a naval command and control model within the next one and a half years and to feed the results into SLOC (or RASIM) to measure the effects of alternative command and control systems on outcomes at the tactical/operational level.

43. The aim in the longer term is to create a new and more complete hierarchy of ground combat models including a realistic representation of command and control and of manoeuvre warfare. The intention is to see how far it is practicable to make this conform to the evolving US high level architecture.

44. Looking further to the future, FFI are funding a research project on synthetic decision making, exploring the applicability of various advanced techniques such as expert systems, fuzzy logic and neural nets. As a means of assessing the techniques, a number of simple models are being developed. One of these concerns decisions to allocate and reallocate air resources between defensive counter-air and offensive counter-air; another is a simple model of combat in which the ground is represented by a lattice where forces advance from node to node and intelligence as to the presence or absence of enemy forces at adjacent nodes is represented in a binary fashion.

### **Force Structure Analysis and Equipment Studies**

45. The primary high level activity is cost effectiveness support for the defence analysis series of studies. Defence Analysis 96 being complete, FFISYS are now engaged on a two year preparatory phase for Defence Analysis 2000, due to complete on 1 April 1999. The aim is to improve the methodology in four ways:

- a) to investigate new ways of operating defence forces, particularly in the anti-invasion scenario (for example, the effect of attacking the logistics chain);
- b) to improve the way in which peace support operations are represented;
- c) to develop ways of prioritising scenarios in order to better represent the flexibility of forces;
- d) to respond to the concern of the Chief of Defence that previous studies were too focussed on one or two scenarios and that scenario methods are perhaps not the best approach; if possible investigate more generic approaches to modelling resulting in forces which are more robust to variation in scenario.

46. Defence Analysis 96 covered the anti-invasion scenario, crisis response, peace support operations, defence against limited attack (eg against the civil infrastructure) and peacetime activities. Defence Analysis 2000 is likely to have a similar scope. The relationships between FFISYS, CHoD staff and MoD are also likely to remain the same with FFISYS reporting direct to CHoD who in turn advises MoD. However, at the same time all results will be made available direct to MoD which is represented on the Project Advisory Group. There is some concern within CHoD staff that FFISYS is too influential with MoD and its analytical advice should reach MoD only by way of the CHoD staff so that it can be more effectively moderated by military experience.

47. Defence Analysis 96 was funded 50% by CHoD and 50% by FFI, but for Defence Analysis 2000 CHoD has increased his proportion to 70%. FFI regard their 30% funding as an essential means of ensuring their independence in deciding what is included in the study.

48. A major problem with such a high level study is integrating the contributions of the three services and indeed of very different roles. This means that analysts cannot easily fall back on the excuse that while their results may not be accurate in absolute terms they are good enough for comparing one option with another. The range of measures of effectiveness is so large and so different in metric that analysts are forced to face up to the need for better absolute accuracy.

49. In recent years the most important equipment study has been of the new combat aircraft and FFISYS had until recently covered all aspects, including the industrial implications of the decision, and had briefed Ministers directly. In early 1997, however, when the choice of aircraft had been narrowed to two contenders, overall control of the project was passed to the Air Force Materiel Command which became the customer for continued FFISYS support.

50. The roles that the new aircraft will have to fulfil are not entirely clear. We were told that traditionally the Air Force has had air defence as its first priority and the emphasis of models has in the past been on air combat. Now, however, ground attack has become of high priority and while the Air Force has a preference for deep

strike, the Army is looking for close air support. Unfortunately, with current models, air-to-ground attack performance is not a good discriminator between aircraft options. Also, because air defence is relatively insensitive to variations in scenario, there is little experience of scenario development in the Air Force.

51. Within the Air Force, the Air Materiel Command is responsible for all acquisitions, including the purchase of services from FFI. However, an office within the Air Staff co-ordinates the needs for FFI services across all the main departments.

52. The other main current equipment study has been of the future frigate where numbers, types and quality of sensors and weapons, roles and costs are all being addressed.

53. A number of studies of command and control system have been carried out and the most important of the current ones would seem to be the support for the development of an operational concept for the land battle.

### **DISCUSSIONS WITH CUSTOMERS**

54. The Review Group was able to interview FFISYS's most important customers during the study. We had an interview with General Solli, Chief of the Defence Staff, at the beginning of the study in August at which he set out his view of the role of FFISYS. During the subsequent field work in October we had discussions with the following staff:

Maj. General Trond Moltzau	Deputy Chief of Staff, Plans and Policy
Brigadier Thor Olai Skullerud	Director, Planning
Col. R Haugen	HQ/CHoD - Army Staff
Col. A. Hamang	HQ/CHoD - Air Staff
Capt. Jarle Naess	HQ/CHoD - Navy Staff
Cdr. Ketil Olsen	HQ/CHoD - Navy Staff
Mr. Svein Styrvold	MoD
Mr. Espen Skjelland	MoD

55. During the initial interview General Solli emphasised the high value he placed on the work of FFISYS and instanced as examples the successive Defence Analysis force structure studies and work on procurement issues, such as the new combat aircraft, the new frigate, a missile equipped torpedo-boat and a submarine launched missile. His responsibilities were limited to tasking FFI and ensuring that he got what he paid for in the way of advice. The professional development of staff at FFI and the development of models for future studies that might be requested were matters for the management of FFI and the balance of funding between annual budget and direct tasking reflected this.

56. All customers were generally appreciative of the work of FFISYS, particularly the Defence Analyses 91 and 96. These regular overall force structure studies were now regarded as the most important tasks of FFISYS, and although the earlier analyses were essentially bottom-up, it was hoped that more top-down might be possible in the

future. Also, the interaction between military staffs and FFISYS was considered to be close and sufficiently frequent.

57. Two areas singled out by the military customers as specially valuable were the work on security policy and the low level tactical modelling, but a number of weaknesses were also identified. The modelling of joint operations was thought to be inadequate and at this level especially a high-level (top down) model was required. It was suggested that the level of military operational competence in FFISYS was not as high as it should be and FFI thought that they had more military expertise at the operational level than in fact they had. This led them sometimes to give advice which was based on opinion rather than on analysis of facts.

58. Defence Analysis 96 had suffered from a number of problems, some carried over from Defence Analysis 91 on which the later work was based and some due to insufficient time being available to carry out the necessary iterations. In particular the treatment of costs was felt to be weak, although problems in this area may have been due to poor data being supplied to FFISYS. Other weaknesses noted were in economic analysis, in the modelling of manoeuvre warfare and in the representation of the effectiveness of long range systems.

59. There was a feeling that the military operational competence in FFISYS is less than it should be and it was planned to improve it by deploying one additional full time Army officer and several officers part-time. FFISYS would prefer them all to be full time secondments but this is reportedly not possible.

60. More generally, there was some concern that FFISYS could not respond to short term requests and they had a tendency to focus on work that they found interesting at the expense of work regarded as more pressing by the military staffs. [We take the liberty to observe here that this is a situation likely to arise since FFI has substantial direct funding but one cannot conclude that FFI has made the wrong priority.] There was also a complaint that FFISYS analysis goes direct to MoD before the study by CHoD is complete and the appropriate military judgement can be applied to the FFISYS work. This was regarded by military customers as a particularly important weakness since models could not adequately represent many military factors.

61. The MoD representatives emphasised that FFI was directly responsible to MoD and that the most important feature of the Systems Analysis Division is its ability to integrate economic, military and international affairs factors. In this respect it was unique. Studies specifically for MoD tended to be strategic in nature and paid for out of the 45% basic funding of FFI. There was a need to strengthen the economic side of the division which was recognised by FFI.

62. In short, although they had some criticisms, the customers without exception regarded FFISYS as making an important contribution and praised the quality of their work overall.

## **DISCUSSION**

### **Organisation and Mode of Working**

63. The formal organisation of FFI was explained to us in briefings and documents. Responsibilities seem to be well understood, accepted and respected. During the interviews, we did not detect any sign of discontent over this. Indeed, we were surprised at the uniformity of view on the part of everyone we interviewed.

64. Dr Solstrand is the current head of FFISYS and the high regard in which the division is held both inside and outside of Norway is in very large measure due to his leadership. The turnover in the staff is, however, fairly high and the average age unusually low. Under such circumstances one might fear that the division has become too dependent on Dr. Solstrand, and perhaps vulnerable should he for some reason leave. With the appointments of the two other directors of research, steps have been taken to reduce this potential vulnerability. Each of them is responsible for a portfolio of projects from all activities in the division. We consider this flexibility in management allocation is a robust form of leadership.

65. FFI is able to adopt a very independent stance for three main reasons:

- a) It reports direct to the MoD quite separately from the military staffs.
- b) It is for all practical purposes in a monopolistic position, since the military staff cannot easily look outside for advice.
- c) Its funding is comprised of a basic budget amounting to 45% of total income with 55% coming from customer funded projects. Thus it can enhance the funds available from its own budget to carry out work that the customer may not be willing to pay for but FFI believes to be important.

Moreover, there are no scientific advisory staff with experience of defence analysis on CHoD staff who can question the scientific quality of FFISYS analysis and advise the customers accordingly. Even the one or two staff in MoD with experience of FFISYS do not appear to be employed in that role. This is not necessarily a weakness, because given the total number of analysts likely to be available in a small MoD, any reallocation of staff between FFISYS and the customer organisation (along the lines, say, of UK practice) is likely to have the result of reducing the already small team available at the institute. However, it does place heavy responsibility on the management of the Systems Analysis Division to ensure that the work of their staff is exposed to sufficient critical review and this is often difficult in the closed environment of defence analysis.

66. While preserving FFI's independence, the present funding system might be expected to serve two other purposes:

- a) encouraging customers to be more conscious how money is spent and to demand 'value for money';

- b) encouraging FFI to be more customer-orientated and to pay more attention to delivering value for money.

In the current monopoly situation, it is difficult to judge whether these mechanisms really work and the fact that both FFISYS and the customers are satisfied with the status quo is not convincing evidence in its favour.

67. All studies undertaken at FFI are organised as projects, headed by a project leader. Members of a project team may come from more than one division, but often a sub-project is defined with members from only one division. This multi-divisional approach seems likely to encourage collaboration although it may occasionally diminish the priority accorded to the OR.

### Security Policy Studies

68. The duration of security policy studies is rather less than is usual for OR studies, but they are nevertheless of relatively long duration, often self initiated, and paid for out of the FFI's budget rather than by the customer. However, they are subject to approval by the Proposal Review Group. Moreover, contacts with MoD customers tend to be rather infrequent and, in spite of MoD's assurance that they valued the work of the group and FFISYS's argument that the present relationship enables the security policy group to have a long range outlook, we got the impression that their studies were unlikely to be a priority for MoD and that their direction is largely self motivated. This is in sharp contrast with the similar group at FOA who appeared to be called in for advice by the Swedish MoD on a day-to-day basis. FFI apparently has no clear strategy for the development of the group and it has no mandate to contribute to debate in the nation as a whole.

69. We were also surprised at the relatively limited distribution of the reports in view of their interest to society as a whole. It was put to us that members of the group contributed articles and papers to journals, newspapers and conferences and we were shown examples. However, these are treated as unofficial and there is no central record which can be regarded as part of the corporate memory of FFI.

70. Two reasons were given for the group's lack of involvement with the day-to-day problems of MoD and MoFA. There are security policy groups in the HQ's of both ministries and MoD is as likely to turn to NFPI or to the intelligence staff for short term advice. Secondly, it was said that the group at FFISYS was simply unable to react quickly enough. In such circumstances it is perhaps not surprising that there seemed to be a lack of commitment to security policy studies on the part of members of the Project Advisory Groups and that FFISYS are not usually invited to comment on policy documents in draft. We could not avoid the impression that this apparent lack of interest on the part of customers is demoralising for staff.

## **Cost Analysis and Defence Economics**

71. Although the group covering cost analysis and defence economics is mainly staffed by economists, most of its work is concerned with cost estimating, an activity which in other countries is usually undertaken by engineers and, occasionally, mathematicians. This may be the reason why the models used are of the bottom-up accounting type requiring a great deal of detailed data. This type of model is appropriate for the defence analysis work, where the total cost of the three services is required, but it has some disadvantages for estimating the now common life cycle cost (LCC) required for cost effectiveness studies.

72. Detailed estimates of the costs of equipment still under development are often unavailable and the support costs of new equipment are notoriously difficult to estimate. We were therefore surprised to find that no parametric models based on past project data were used at least as a check on bottom-up estimates. On the other hand, the group is unusual in allowing for the cost escalation fundamental to defence projects when estimating the costs of projects likely to come into service 10 years or more in the future. Also future cash flows are not discounted as is common in other countries but, since there are arguments for and against doing this for defence projects, we merely note the fact.

73. More significantly, the main output of the models used for cost effectiveness studies is a single point estimate and the method of allowing for uncertainty seemed unnecessarily crude and dependent on arbitrary subjective judgement. Statistical analysis of cost and time data from past projects can be used to make judgements of uncertainty more objective. There appears to be no attempt to assess quantitatively the risks of delay and cost overruns for individual projects or the risk of costs of a total programme of projects exceeding the budget. This is an area of growing importance as defence budgets, and hence the money available for new equipment procurement, reduce.

## **Operational Research Models and Studies**

74. Operational research is the core activity of FFISYS and most of the staff are engaged in this area of work. During our main visit, we covered low level and high level OR in separate interviews but in this section we adopt a different approach, discussing first the overall modelling structure and then making some brief remarks on the studies for which it is used.

75. The OR models used by FFISYS have gradually accumulated over the years, each developed in an ad hoc way to meet the requirements of specific studies. There is much to be said for this approach and for two main reasons. First, it recognises that the emphasis of OR is essentially on problem solving by whatever means are appropriate to that particular problem. Second, it recognises that even the most sophisticated model is a crude and biased representation of reality, which represents in detail only those factors which are amenable to modelling, ignoring many that are equally important but for which suitable data is not available. This argues for new models specifically designed to meet the needs of each new study but this has for a

long time been impracticable because of the investment in time and effort required as more and more complex problems have been tackled. Instead, models are continually extended and adapted for new problems as they arise and such is the pace that neither the original models nor the changes are adequately documented, models fall temporarily out of use, those who understand them move on to other work and their models become very difficult to resuscitate when they are required. Moreover, for higher level studies, models usually require as inputs the outputs from more detailed lower level models which exacerbates the difficulty.

76. This is a universal problem which has been made more intractable by the tendency of most organisations to squeeze investment in model building in order to meet a growing demand for studies. The results are as evident in the modelling structure that was described to us as in many other organisations. There is a consensus across the OR world that in order to carry out force structure studies at the highest level and at the same time cost-effectiveness studies on specific equipment options, a hierarchy of models with well designed interfaces is required. FFISYS have made a start by adopting two object oriented languages as standards (Modsim and Smalltalk). Very sensibly they have decided to insist on these standards only for models expected to require more than one man-year of effort to develop. There will always be a need to make exceptions.

77. We applaud the initiative to form a modelling strategy group charged with reporting by the end of the year and we were informed of the likely conclusions of their report. Previously, almost all design and implementation of models has been carried out in-house because the interface between the two activities seemed blurred. Now that programming has become an industry and there exists tools which enable specification and design to be developed to a stage just short of coding, this may change. However, the need for the analyst carrying out a study to thoroughly understand what the models he is using do and do not represent must be regarded as paramount. Also, it is important that not all models are dependent on data only obtainable through the use of lower levels in the hierarchy. Complex systems are often best understood through simple high level models which reflect their essential characteristics, stripped of unnecessary detail.

78. The emerging strategy is far-reaching and, if successfully implemented, should result in a combat model structure as good as, if not better than, any known to the team. We were particularly impressed by the proposed approach to the incorporation of command and control in combat models. However, the investment required will be considerable and the adequate funds to document, maintain and update the models must be provided, otherwise they will once again decline into obsolescence. This requires a new determination on the part of analysts to reserve an appropriate percentage of the division's turnover and a recognition of the need by customers.

79. We welcome the efforts that have been made to collaborate on model building with other nations and the recognition that simply buying in foreign models has considerable disadvantages, not least in losing the learning about the real world which is one of the reasons for building models.



80. Turning to the studies themselves, we note that improvements in methodology are to be made before Defence Analysis 2000 begins. The end of the Cold War has meant that defence planners must take account of a much wider range of scenarios than hitherto. Not surprisingly, this has led to a call for approaches which are more generic and less dependent on the specifics of scenarios. However, previous attempts, notably by US analysts, to represent military capability by scores based on an aggregation of the contributions of different types of force (bean counting), while useful at the arms control level, are unsuitable for force structure or investment appraisal studies. It is thus not easy to see any alternative to analysis generalised from the results of a range of different scenarios.

## **CONCLUSIONS**

81. FFISYS enjoys a well deserved international reputation as one of the most influential defence OR groups in the western world. The number of analysts employed is an order of magnitude less than in the UK, although the number of defence decisions which have to be made is not very dependent on relative nation size. It is not, therefore, very surprising that some types of decision and of methodology are less well covered than are others.

82. FFISYS has a well qualified staff. For personnel in high demand in private industry (IT, economics), recruitment was said to be difficult and loss of personnel a threat. We understand the wish to be able to negotiate salaries on an individual basis, but in the long run we think that FFI will still not be able to compete as far as salaries are concerned. In this situation we consider the generous attitude towards continued education and training to be a very good "substitute", particularly for keeping young people for an extended period. We were concerned at the shortages of staff at level 4 and level 5. It is essential that the loss of senior key personnel can be prevented by offering reasonable economic compensation and more involvement with the day to day work of MoD and the military staffs might help.

83. The most noticeable characteristic of FFISYS is its emphasis on long-term studies, with very little short term quick response help to hard-pressed decision makers in the military staff or in MoD. This was frequently brought to our attention but, in view of the size of the group and the importance of the long term studies, particularly the Defence Analyses, it is understandable that the management should have chosen to concentrate on the long term. Nevertheless, it is a pity that this should be so since there are advantages for both the analysts and for the customers in achieving a balance between long term studies and short term advice on day-to-day issues. For one thing, involvement in day to day issues ensures that analysts are closely in touch with the real world of defence decision making and this should help them take a more realistic view of the results of their long-term studies. It might reduce the criticism that FFISYS have sometimes offered advice which they were not sufficiently experienced in military matters to give, instead of sticking strictly to the scientific analysis in which they were expert. One way of achieving greater involvement would be to persuade the HQ staffs to include FFISYS on the circulation of draft policy papers leaving it to them to decide whether they could make useful quick comments, based on back of the envelope calculations or on the result of previous studies.

84. This lack of contact with day-to-day decision making was particularly difficult to understand in the case of the security policy staff and seemed a waste of a recognised centre of expertise. One might have expected the long-term studies programme to have been used, at least partly, to generate a basis of expertise which could be drawn on for advice on short-term policy making. But this appeared not to happen and we were even told that communication with CHoD was better than with the MoD for whom the security policy staff mainly worked. We recommend that the management should seek to persuade MoD of the value of closer involvement by the security policy staff in their day-to-day policy making. We believe that this would have the effect of increasing the commitment of MoD members of Project Advisory Groups. The distribution of reports needs to be reviewed and expanded with the aim of influencing the climate of opinion rather than the point of view of the immediate customer. Finally, on a minor point, it would be useful to collect together into the library and record all external open literature publications, papers for conferences, articles for magazines, etc. | ?

85. We were surprised to find little evidence of either of OR studies or of the development of models for the representation of peace support operations. The only work in this area so far appears to be by the security policy staff. We would have expected much greater involvement by OR staff in view of its increasing importance for defence policy.

86. FFISYS has a substantial range of models of military operations at the technical, tactical and operational levels, but many are out of date and poorly documented so that they are difficult to bring back into use. It would appear that pressure to undertake more and more studies has led to under investment in the modelling structure and we welcome the review of modelling strategy due to be completed by the end of the year. There are weaknesses at the highest level in the representation of joint operations, perhaps in the representation of manoeuvre warfare and in command and control. The review of strategy is particularly opportune in view of the need to take account of a much larger number of scenarios than in the past. The strategy that appears to be emerging from this seems comprehensive and we commend it. However, substantial investment will be needed and funds to support the new structure must be much better protected than in the past.

87. In our view, FFISYS has a well-balanced attitude to wargaming. It is disappointing that their attempts to improve the continuation training of commanders through the incorporation of OR models into CAX has been unsuccessful and we support their intention to try again.

88. Cost is more important in defence decision making than ever before. This is recognised by FFISYS and is reflected in the size of the team. However, we suggest that the balance of skills within the team should be reconsidered and more specialised cost engineers employed. The cost models used at present are of the bottom-up accounting type. They seem cumbersome and over dependent on detailed data. Where detailed input data is essential, as in the case of KOSTMOD, we recommend that the updating process is made more automatic. We also recommend that for cost-effectiveness studies top-down parametric models should be developed for use at the

that the updating process is made more automatic. We also recommend that for cost-effectiveness studies top-down parametric models should be developed for use at the early stages of projects and as a check on the accounting models. Moreover, we believe that the assessment of uncertainty is based too much on arbitrary subjective judgements and more objective approaches based on experience of past projects should be developed.

89. Although there are a number of economists on the FFISYS staff, no studies of the Norwegian or European defence industries seem to have been carried out. We find this surprising in view of current pressures on defence budgets, the changed international defence environment and, in particular, the changes in the US defence industries.

90. FFISYS has traditionally carried out almost all model building and studies in-house. Clearly this has advantages where security and political sensitivity are concerned, but it limits the degree to which defence can take advantage of methods and skills developed in the commercial sector. We note the small amount of external advice commissioned by the security policy staff and the intention to transfer the coding of new models to the developing programming industry, but we suggest that there are other areas such as 'soft' OR methods, cost estimating and risk analysis where it would be advantageous to look outside for assistance.

91. Finally, none of our suggestions for improvement should be taken as criticism of the achievement of FFISYS. The work we were shown and the staff we interviewed were of very high quality. The arrangement whereby FFI is funded partly through a budget delegated from MoD and partly by direct contract with fund holding military customers seems to have successfully preserved its independence while ensuring accountability. In spite of the tensions and differences of view inevitable if independence is to be maintained in practice, FFISYS is clearly highly valued by its customers and, more important, trusted.

## ANNEX A

### MEMBERSHIP OF THE REVIEW GROUP

Mr David Faddy	UK
Professor Thomas G Hart	Sweden
Professor Olav Holt	Norway
Professor L Peter Jennergren	Sweden
Mr Jon Ostensvig	Norway

**REVIEW OF THE ACTIVITIES AT FOA 1 AND FEISYS**

**Task Description**

The Review Group shall examine the work of the two divisions with the aim of making an overall assessment of the quality of the research work and its products. Strengths and weaknesses should be highlighted as a basis for further development and improvement. The following list identifies key areas for examination. The list is not meant to be binding for the internal work of the Review Group and the format of reporting.

- a) Research areas and activities
  - Adequacy of coverage
  - Relevance
  - General customer consciousness and understanding of user needs
  - Direction of future research
- b) Research methods and tools
  - Scientific quality
  - Coverage and ability to update
  - Balance of internal and external development
- c) Transfer of research results
  - Ability to publish
  - Balance of scientific and "user-oriented" reports
  - Report quality and usefulness
  - Other means of communicating results
- d) Collaboration
  - Scope and orientation
  - National versus international collaboration
  - Collaboration with other research organisations and universities
- e) Personnel
  - Academic background
  - Scientific and educational update
  - Strategy for personnel development
- f) Organisation
  - Internal structure
  - Structural relationship with customers

The work is scheduled for the fall '97 period, preferably in two rounds - the first to acquire basic insight into the kind of work and the mode of operation of the two divisions, the second to probe deeper into selected, important areas.

**SUMMARY OF THE MAIN DIFFERENCES BETWEEN FFISYS AND FOA1**

**Size and Scope of Work**

FOA1 is approximately twice the size of FFISYS and the scope of its activities is much wider. However, the numbers of staff engaged in operational research are comparable.

**Structure**

FFISYS is organised as a single group of staff from which project teams are formed under a triumvirate of Directors of Research. FOA1 is organised into seven separate departments, each with a departmental head. Only one of these is exclusively concerned with OR (FOA11) but others carry out some work which would also be regarded as OR in nature.

**Analyst/Military Staff Working Relationships**

FFISYS has military staff seconded to it and carries out all studies in-house. FOA1 has no military staff and most of the OR staff are outposted to military HQ branches to carry out OR studies as an integral part of military led teams.

**Funding**

FOA1 depends almost entirely on funds provided by customers for specific tasks whereas only 55% of FFISYS funds are provided by customers for specific tasks and 45% comes in the form of a basic budget from MoD.

**ANNEX D**

**LIST OF EFISYS STAFF INVOLVED IN DISCUSSIONS**

Harald Andas  
Bent Erik Bakken  
Trond Bergene  
Fredrik Dahl  
Else Helene Feet  
Iver Johansen  
Tor Langsaeter  
Arne Nessel  
Jonny Otterlei  
Reidar Skaug  
Ragnvald Solstrand  
Jan Erik Torp