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Evaluation of NKS Research Activities during 2002 - 2005

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Abstract

NKS research work during the years 2002 – 2005 and its results have been evaluated against a set of criteria defined by the NKS Board. The evaluation encompassed the NKS-R (reactor safety) and NKS-B (emergency preparedness) programs and was conducted by two persons per program. The mode of work of the two evaluation teams was adapted to the special conditions of the program at hand, one being aimed more at the nuclear industry and the other at a more academic surrounding; in both cases, however, with great involvement of relevant national authorities. The findings of the evaluators are presented in this report. Financing and participating organizations, end users, deliverables, quality aspects, cost-benefit issues, time schedules, budgets and related issues are discussed. Finally, the sections on NKS-R and NKS-B, respectively, include conclusions and recommendations for future NKS work.

Key words

accidents; ageing; application; automation; call for proposals; competition; contamination; control room; cost calculation; criteria; decision support system; decommissioning; deliverable; dose assessment; emergency preparedness; end user; environment; evaluation; funding; indicator organisms; in-kind contribution; intercomparison; interview; measurement; monitoring; network; Nordic dimension; nuclear safety; objectives; organizational issues; plant lifetime management; probabilistic safety analysis; program manager; protection; quality assurance; questionnaire; radiation; radioactive; radioecology; release; remediation; risk analysis; safety culture; sampling; spectrometry; thermal hydraulics; waste

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This is NKS

NKS (Nordic Nuclear Safety Research) is a scientific cooperation program in nuclear safety, including emergency preparedness and radiation protection. It is an informal forum, serving as an umbrella for Nordic initiatives and interests. Its purpose is to carry out joint activities producing seminars, exercises, scientific articles, technical reports, manuals, recommendations, and other types of reference material. This material offers guidance to concerned ministries, authorities, research establishments and enterprises in the nuclear field in their decision-making.

The work is divided into two main branches:

NKS-R	Reactor Safety including Decommissioning and Radioactive Waste
NKS-B	Emergency Preparedness including Radioecology and Emergency Preparedness Related Information and Communication Issues

Normally, only activities of interest to financing organizations and other end users are carried out. The results should be practical and directly applicable. The main financiers are:

- The Danish Emergency Management Agency
- The Finnish Ministry for Trade and Industry
- The Icelandic Radiation Protection Institute
- The Norwegian Radiation Protection Authority
- The Swedish Nuclear Power Inspectorate
- The Swedish Radiation Protection Authority

Together with support from a number of additional financiers in the nuclear field, the total NKS budget for 2005 was some €1.0 million (DKK 7.5 million). To this should be added contributions in kind by participating organizations, worth approximately the same amount, without which this program would not be possible.

The region in question is the five Nordic countries, i.e., Denmark (including the Faroe Islands and Greenland), Finland, Iceland, Norway and Sweden. With a total population of some 24 million people, and a common cultural and historic heritage, the Nordic countries have cooperated in the field of nuclear safety for approximately half a century. Informal networks for exchange of information have developed throughout the years, strengthening the region's potential for fast, coordinated and adequate response to nuclear threats, incidents and accidents. NKS has served well as a platform for such activities.

This Nordic interest in cooperation and pooling of resources via NKS is due to the large number of nuclear installations and activities in the region. There are four nuclear power reactors in operation in Finland, and one (Olkiluoto 3) is under construction. Sweden has 12 nuclear power reactors. Of these, 10 will continue operation and two have been permanently shut down (Barsebäck 1 and 2). Preparations are being made to decommission the Barsebäck reactors. There are research reactors in Denmark, Finland, Norway and Sweden. The three Danish reactors have been closed and decommissioning work has started. The reactors in Finland and Norway are still in operation. The two Swedish research reactors have been shut down recently and face decommissioning. In Sweden there is also a nuclear fuel production plant in operation. All five Nordic countries have interim

storages for radioactive waste. Finland, Norway and Sweden have final repositories in operation for low and medium level waste. In Finland and Sweden work is in progress to allow construction of final repositories for spent fuel. Apart from nuclear installations in the Nordic countries, there are commercial, research and naval nuclear reactors and other nuclear installations in surrounding eastern and western countries.

Therefore, NKS with its program for nuclear safety including radioactive waste, environmental issues, emergency preparedness, radiation protection and information is of common interest to all five Nordic countries. The hallmark of NKS is a spirit of sharing – all results are available free of charge, not only to the NKS family but worldwide. When quoting NKS material, a reference to the source will be appreciated.

A historical overview is given in a book entitled “Half a Century of Nordic Cooperation. An Insider’s Recollection.” The author is Franz R. Marcus and the book can be ordered free of charge from the NKS Secretariat.

About this report

The NKS-R program has been evaluated by Risto Sairanen (STUK) and Per Persson (independent consultant), and the NKS-B program was evaluated by Per Hedemann Jensen (DD) and Tore Lindmo (NTNU). The material has been compiled by Torkel Bennerstedt (NKS) and edited by Annette Lemmens (FRIT). On behalf of the NKS Board, additional information on NKS policy and activities has been supplied by Lars Gunsell (SKI) and Sigurður M. Magnússon (GR), as needed. NKS is grateful for the significant contributions made by the authors to evaluate and help improve the overall NKS structure and mode of work as well as programs and activities.

Summary

Following an NKS Board decision in November 2005, NKS work and results from the years 2002 to 2005 have been evaluated. The two programs, NKS-R (reactor safety) and NKS-B (emergency preparedness) were evaluated separately and according to a set of criteria adopted by the Board. See Appendix 1.

NKS-R: The reactor safety program

In the case of NKS-R, the criteria were translated into a list of 14 questions by the evaluators. Answers to the questions were collected from three sources:

- interviews of persons from Finland and Sweden having experience of working with NKS-R
- a survey sent to end users of the NKS-R research results, and to activity participants
- review of NKS-R deliverables by the evaluators

Considering the limited level of funding, the achievements of the NKS-R work in 2002-2005 have been very good. Only a few delays have been observed. In a vast majority of cases, the activity leaders have conducted their activities according to plans and in a cost-effective way. The end users

have considered the results applicable. All finished activities have fulfilled the formal NKS requirement of producing final documentation.

Some NKS objectives have not been completely fulfilled in NKS-R. Building of Nordic networks has been only occasionally achieved. Most of the activities have been mainly conducted by the leading organization. Contacts with power plants and with other relevant established Nordic cooperation groups have been scarce in some cases.

The NKS-R evaluators recommend that the Nordic cooperation aspect should be enhanced in the future. Contacts with other established Nordic cooperation groups, with the end users and with NKS-B should also be reinforced.

Distribution of the NKS-R results should be improved, e.g., by arranging seminars presenting the results of the program activities.

Education activities, especially for the younger generation, could be a regular feature of NKS-R. The education could efficiently utilize the facilities available in various Nordic countries.

NKS-B: The emergency preparedness program

The NKS-B activities have been evaluated against activity proposals and against their scientific merits. The quality of the deliverables varies considerably. Also, the cost-effectiveness, i.e., the "return of the investment" in the different activities varies, as do the scientific perspectives of the activities. Many of the activities, however, have the potential of being further developed within Nordic research programs.

Activities on *measurement technology* have been a very valuable part of the NKS-B program portfolio. Nordic countries possess expert competence in this field, which is also appreciated on the European level. Nevertheless, radiological measurements constitute an expertise only mastered by few institutions in each of the Nordic countries. Activities within NKS therefore constitute an opportunity to further develop and maintain this competence as well as to work out common protocols and procedures that will ensure coordinated actions within the Nordic countries in case of an emergency. The activities on field measurements and laboratory-based analyses are highly relevant and very valuable results have been obtained from both field exercises and laboratory intercomparisons.

The purpose of the *radioecology* activities has been to establish reliable data for prediction of possible dose to humans from different ecosystems, to be used in decision-support systems, and to search for new organisms accumulating radionuclides in various ecosystems. From the published reports of NKS activities in this field, it is not always clear how the results will be utilized in a systematic manner to further strengthen the expertise within these two areas of radioecology. To improve decision-support systems, critical analyses to identify which data are most needed to strengthen system performance should be made and the data be acquired through focused activity work. The search for new accumulating indicators should be limited to a few species relevant for the Nordic countries and the effort then focused on a systematic long-term monitoring of such species.

The *emergency preparedness* activities have been well-anchored. In general, all activities have been relevant for emergency preparedness and they fulfil the criteria set up in the NKS-B program. The activities have contributed to maintain and building up competence and to maintain and building Nordic networks between scientists in emergency preparedness disciplines. Transverse collaboration between closely related activities seems to have been rather low but might be improved in the further work on integrating the activity results into broader decision-support systems.

Challenges for future NKS work on emergency related activities will be careful considerations on the balance between research-oriented and more practical-/routine-oriented activities, more clear communication of the activity results, integration of such results into decision-support systems, better integration of NKS activities with relevant EU activities, and inclusion of university departments in research activities.

Sammanfattning

I november 2005 bestämde NKS' styrelse att NKS-arbetet och dess resultat mellan åren 2002 och 2005 skulle utvärderas. De två forskningsprogrammen, NKS-R (reaktorsäkerhet) och NKS-B (beredskap), utvärderades var för sig och i enlighet med direktiv från styrelsen. Se Appendix 1.

R-delen utvärderades av Risto Sairanen (STUK) och Per Persson (fristående konsult), och B-delen utvärderades av Per Hedemann Jensen (DD) och Tore Lindmo (NTNU). Utvärderarnas rapporter har sammanställts av Torkel Bennerstedt (NKS) och redigerats av Annette Lemmens (FRIT). Lars Gunsell (SKI) och Sigurður M. Magnússon (GR) har vid behov och på styrelsens vägnar lämnat kompletterande information om NKS' policy och verksamhet under utvärderingens gång.

NKS-R: Reaktorsäkerhetsprogrammet

Utgående från utvärderingskriterierna utarbetade utvärderarna en lista med 14 frågor. Svar inhämtades på följande vis:

- Personer i Finland och Sverige med erfarenhet av arbete inom NKS-R intervjuades
- En enkät sändes till slutanvändare av forskningsresultaten, och till deltagare i NKS-aktiviteterna
- Rapporter, seminariematerial och annan information från NKS-R studerades av utvärderarna

Med tanke på de begränsade resurserna är resultatet av arbetet i NKS-R under åren 2002 – 2005 mycket bra. Förseningarna har varit få. I de allra flesta fall har de aktivitetsansvariga följt de uppgjorda planerna och arbetat kostnadseffektivt. Slutanvändarna har bedömt resultaten som användbara. Alla avslutade aktiviteter har i enlighet med NKS-kraven avrapporterats i en slutrapport.

Vissa NKS-mål har inte uppfyllts till fullo. Nordiska nätverk har skapats bara i en del fall. De flesta aktiviteter har huvudsakligen genomförts av den organisation som haft ledningsansvaret. Kontakterna med kraftindustrin och andra relevanta etablerade nordiska samarbetsgrupper har varit knappa i en del fall.

Utvärderarna av NKS-R rekommenderar att det nordiska samarbetet utökas i framtiden. Kontakterna med andra etablerade nordiska samarbetsgrupper, med slutanvändare och med NKS-B bör också stärkas.

Spridningen av resultat från NKS-R bör förbättras, t ex genom att arrangera seminarier där resultaten av programaktiviteterna presenteras.

Utbildningsaktiviteter, särskilt för den yngre generationen, skulle kunna vara ett återkommande inslag i NKS-R. Utbildningen kunde på ett effektivt sätt använda sig av de faciliteter som finns tillgängliga i de nordiska länderna.

NKS-B: Beredskapsprogrammet

Aktiviteterna inom NKS-B har utvärderats mot aktivitetsförslagen och mot deras vetenskapliga förtjänster. Kvalitén av levererade produkter varierar avsevärt. Även kostnadseffektiviteten (det vill säga hur stor nytta man haft av de nedlagda resurserna) i de olika aktiviteterna varierar, och det gäller även aktiviteternas vetenskapliga perspektiv. Men många av aktiviteterna har potential att utvecklas ytterligare inom nordiska forskningsprogram.

Aktiviterna rörande *mätteknik* har varit en mycket värdefull del av NKS-B. De nordiska länderna besitter expertkompetens, vilket uppmärksammas även på europeisk nivå. Men bara ett fåtal organisationer i vart och ett av de nordiska länderna behärskar radiologiska mätningar. Aktiviteter inom NKS ger därför en möjlighet att upprätthålla och utveckla denna kompetens. Samtidigt kan gemensamma protokoll och procedurer utarbetas i Norden, som underlättar koordinerade nordiska insatser i ett beredskapsläge. Insatserna avseende fältmätningar och laboratorieanalyser är mycket relevanta, och mycket värdefulla resultat har uppnåtts både vid övningar på fältet och vid jämförelsemätningar på laboratorier.

Aktiviteterna inom *radioekologiområdet* har haft två syften. Det ena har varit att få fram vederhäftiga data för att kunna förutsäga dosen till människa från olika ekosystem, att användas som underlag i system till stöd för beslutsfattare. Det andra har varit att kunna studera nya möjliga organismer som ackumulerar radionuklider i olika ekosystem. Av de publicerade NKS-rapporterna på detta område framgår inte alltid klart hur resultaten ska användas på ett systematiskt sätt inom dessa två delar av radioekologin. För att förbättra systemen för stöd till beslutsfattare borde kritiska studier genomföras för att identifiera vilken typ av data som mest behövs för att förbättra systemen, och sådana data borde sedan tas fram genom fokuserade insatser. Studierna av nya ackumulerande organismer borde begränsas till ett fåtal arter som är typiska för de nordiska länderna och arbetet inriktas på långtidssudier av dessa arter.

Aktiviteterna på *beredskapssidan* har varit väl förankrade. I allmänhet har alla aktiviteter varit relevanta för beredskapen och de uppfyller kriterierna som gäller för NKS-B. Aktiviteterna har bidragit till att upprätthålla och utveckla såväl kompetens som nordiska nätverk mellan vetenskapsmän inom olika delar av beredskapen. Gränsöverskridande samarbete mellan närliggande fackområden tycks ha varit sällsynt men skulle kunna utökas i ett kommande arbete med att integrera resultaten i bredare beslutsstödssystem.

En utmaning för framtida beredskapsarbete inom NKS är balansen mellan forskningsaktiviteter och aktiviteter inriktade på praktiska frågor och rutiner. Andra utmaningar är tydligare resultatspridning,

implementering av de uppnådda resultaten i beslutsstödssystem, bättre integration av NKS-aktiviteter med EU-projekt, och ett ökat deltagande av universitetsinstitutioner i forskningsarbetet.

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Introduction

The NKS structure and activities are evaluated fairly regularly. The last evaluation was reported in NKS-66 of November 2002 and encompassed research results as well as organization and administrative support regarding the years 1998 – 2001. As a consequence of this evaluation, the Board decided to reorganize NKS activities and administration. The new structure and procedures are described below. In November 2005 the Board laid down the directives for an evaluation of the results and new mode of operation of the last 4 years (2002 – 2005). This report presents the findings of the evaluators.

NKS research was reorganized in 2001 in order to improve overall flexibility, transparency and efficiency. The old structure of a handful of rather bulky 4-year projects was abandoned in favor of a structure with a large number of smaller activities divided into two main program areas, each led by a program manager:

- NKS-R: reactor safety, including decommissioning and radioactive waste
- NKS-B: emergency preparedness, including radioecology and emergency preparedness related information and communication issues

Suggestions for new activities are invited through a procedure of Call for Proposals, initiated by the NKS-R and NKS-B program managers. Proposed activities should be well defined and limited in objectives, duration and costs. The proposals are evaluated by the respective program manager and one or more experts and presented at the NKS Board meeting in November each year. Normally, NKS activities are planned and financed for one year at a time and can be prolonged or extended by the Board as appropriate. Thus, the content, duration and funding of the activities will vary over time and between activities, and an element of competition in applying for NKS research funding has been introduced.

The main source of financing of NKS activities is national institutions in the five Nordic countries. The total financing for the years 2002 to 2005 is shown in Table 1, together with main expense items in the same period.

Table 1. NKS financing and expenses for the period 2002-2005 (in DKK, based on yearly accounting reports)

Financing		**Expenses**	
National institutions	27 665 952	Remainder costs 1998-2001	5 428 839
Other sources	2 329 949	Funding of R activities	10 701 768
		Funding of B activities	10 486 930
		Other costs	5 417 630
Total income	29 995 901	Total costs	32 035 167

Thus, unused funds from previous years have been spent to cover the costs. If activity spending in each of the Nordic countries is compared with the financial contributions from the respective countries, as shown in figure 1, it seems that Sweden has a significantly lower "return" than other member countries.

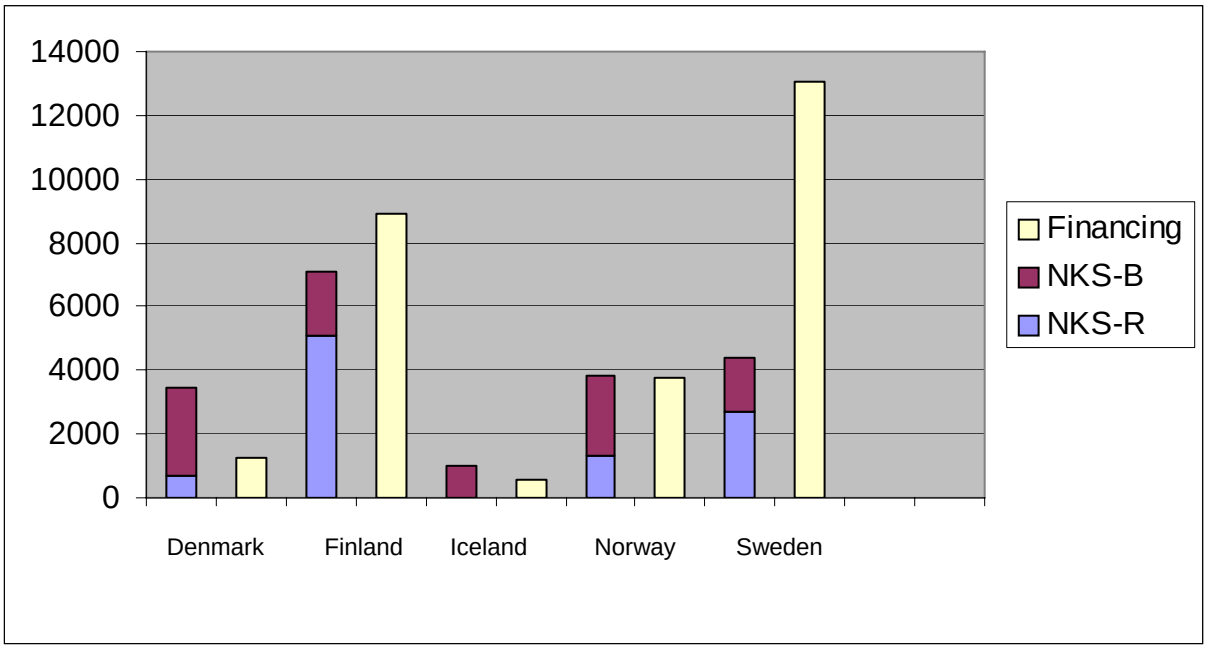


Figure 1. NKS program spending (in 1000 DKK) in individual Nordic countries, compared to financial contributions from the respective countries, based on break-down of data in Table 1 country by country. (NKS-R expenses are allocated to activity leader's country, NKS-B activity expenses have been distributed on participating countries in each activity.)

Since the activities are funded on a yearly basis, all funding decisions and contracts between NKS and the organizations that carry out the work are made for a maximum period of one year. Activities that have a longer duration must apply for a continuation of the NKS funding annually. A final report should be available immediately after finishing the activity. These arrangements ensure that all activities are constantly supervised and evaluated at least once a year.

Program managers were nominated from the beginning of 2002 for the respective areas. Administratively, the two program managers in the new structure replaced the former six project leaders of the NKS 1998 – 2001 program, and "projects" are now normally referred to as activities (although the old term project is still used occasionally). The responsibilities of the present program managers include:

- Managing the activities and proposing new ones
- Ensuring that the program is conducted according to the decisions of the Board
- Interacting with the Nordic end users
- Interacting with the activity leaders, ensuring that the activities are running and being reported according to plans (including budget)
- Reporting to the Board at its meetings

Background information and instructions for the NKS work are given in the Program Handbook (NKS(06)3) and Administrative Handbook (NKS(06)4). In addition, the NKS-R and NKS-B program managers have issued and updated Framework Reports for detailed instructions on the R and B research work.

All NKS activities must be led by an organization based in Denmark, Finland, Iceland, Norway or Sweden. It is allowed and even encouraged to link an NKS activity to other national or international research programs. Non-Nordic partners are not excluded from the program, but they cannot be the leading organization. All results of an NKS funded activity are public and published in the NKS series. No funding can be given to proposals producing confidential results. The reports produced by the activities are published electronically on the NKS website, and the final reports are also printed.

It is intended to keep NKS work open and dynamic by regularly announcing new calls for proposals, and encouraging candidate activities to apply for NKS funding. Applications can be submitted at any time. Practically, most of the applications are received during the first funding round launched in August every year with a deadline for proposals in September. All running activities must also participate in the annual evaluation process if they are to be prolonged.

Applications are submitted to the program manager, who coordinates the evaluation process and presents a funding proposal to the NKS Board. Each proposal is evaluated by experts representing intended end users of the research results. The funding decisions are made by the NKS Board in a meeting usually held in November. The program manager presents the Board with the evaluation results and a proposal for funding distribution, including documented justification of the proposal.

After the Board meeting, the program managers contact the activity leaders who are expected to give their acceptance of the terms given by the Board. If accepted by the end of December, the activities can be contracted and start at the beginning of the following year.

Usually, a small part of the total NKS funding has been reserved for a second round in May.
The basic requirements that all activity proposals, and of course the activities should fulfil are:

- The activity should have a well defined organization.
- Each activity must have a responsible activity leader.
- There must be a detailed financing plan for each activity. All funding sources and in-kind contributions must be indicated in the proposal. For research activities, the NKS funding can normally be no more than 50% of the total funding.
- Each activity must produce documented results.

The organization proposing an activity must submit a plan for the activity. The format of the activity plan is free, but there is a recommended structure given in the framework reports. The activity plan should give a detailed description of the activity as regards the evaluation criteria listed below. In addition, a signed proposal summary form must be submitted to document basic contact information of the activity.

The program manager invites a team of experts to assist with the evaluation. The evaluation team members perform their evaluation independently of each other for each proposal in their research area. The evaluation is done by assigning numerical scores and justification for the scores using the six evaluation criteria listed below.

1. The proposals should demonstrate the Nordic dimension. The Nordic dimension is interpreted here as creation or maintenance of Nordic networks, transfer and build-up of Nordic competence, and involvement of young Nordic researchers and research teams.
2. The technical/scientific content of the proposed activity should meet high international standards, and new developments should be highlighted.
3. There should be distinct and measurable goals both for technical/scientific development and for efforts related to information exchange.
4. The results should be highly relevant for the end users and financing organizations.
5. Participation of young experts in an activity provides additional merit.
6. Linking NKS activities to other international programs or work within, e.g., EU, IAEA and OECD/NEA provides additional merit.

1. Evaluation of the NKS Reactor Safety Program, NKS-R, 2002-2005

1.1 Introduction: Overview of NKS-R activities

1.1.1 Activities in the period 2002-2005

The NKS-R program in the current form started in 2002. At that time it was decided to divide the R program into two themes:

1. Development and Validation (DELI) of assessment methods and new technology. The theme covers challenges related to plant safety assessment and introduction of new technology into the plants.
2. Management and organisation (MANGAN) of safety and quality assurance. The theme covers the challenges related to implementation and assessment of effective safety and quality management, and human performance in different situations.

Seminars can be considered as a third theme.

The present NKS-R program has evolved from activity proposals received in the annual process of Call for Proposals. The objectives and the application process of the NKS-R program are described in the NKS-R Framework report (NKS(05)4).

The bases for funding decisions are the proposal evaluation scores given by the proposal evaluation teams. In addition to the scores, it is a responsibility of the program manager to consider factors influencing the balance of the program. Factors listed in the NKS-R framework report are:

- The program - as a whole - must be balanced geographically. There may be individual activities without a strong showing of co-operation between Nordic countries, but the program must be balanced overall.
- Important Nordic organisations - utilities, authorities, and research institutes - should be involved in NKS-R activities.
- There should be a fair representation of various technical research areas and themes.
- Proposals to ongoing activities can be accepted, on condition that the preceding activity has been well-managed and successful.
- New activities are generally not initiated with activity leaders who have severely delayed NKS activities pending. New activities may be considered after concluding and reporting the delayed activity.

The NKS-R activities during 2002-2005 can be grouped into six research areas:

1. Thermal hydraulics and severe accidents.
2. Organisation issues, safety culture
3. Risk analysis
4. Automation and control room
5. Radioactive waste and decommissioning
6. Plant lifetime management and ageing

The research area of thermal hydraulics and severe accidents has included experimental work and analyses. Experimental activities have focused on condensation phenomena in pressure suppression pools, fission product transport in severe accidents, ex-vessel debris coolability and interactions

between molten fuel and coolant. Condensation phenomena and their loads to structures have also been analytically studied. A different kind of activity in this field was a preparatory project with the objective of establishing a Nordic thermal hydraulic and nuclear safety network.

Organisational issues and safety culture has been a significant research area in the NKS-R program. Three relatively large research projects have been conducted. A contextual assessment of maintenance culture safety and efficiency in Finland and Sweden has been conducted, using the Olkiluoto and Forsmark plants as examples. Safety management in a non-nuclear context has been studied, with the objective of finding relevant insights to nuclear applications. There has also been a research project to define the central reactor safety concepts in a fundamental, logically sound way.

Common cause failure models used in calculations of high redundant systems have been investigated in the risk analysis area. Another activity in the area has been development of a framework for the risk-informed decision making process, also assessing the status of risk-informed decision-making in Sweden and Finland. A relatively new risk analysis activity has the goal to better understand system requirements on the shutdown systems and control rod function in different abnormal situations.

The main NKS-R research project in the automation and control room has focused on traceability and communication of requirements in digital I&C systems development. It has later been succeeded by an activity to facilitate industrial use of the results produced in the first project.

Radioactive waste and decommissioning was introduced to the NKS-R program by a seminar on decommissioning in 2005. At the same time, a research activity was begun to investigate cost calculations with regard to decommissioning and dismantling of nuclear facilities.

Plant lifetime management is another topic that has been added to the program only lately. Two activities have been started in 2005: One for wire system ageing, another for corrosion fatigue of the primary system, especially the reactor pressure vessel.

During the evaluation period 2002-2005, the NKS-R program has consisted of 23 activities. They are listed in Table 2

Table 2. Summary of the NKS-R activities during 2002-2005

Acronym	Activity name	Total NKS funding kDKK 2002-2005	Duration	Leader(s)
PrePool & DeliPool	Condensation pool experiments	1385	2002 -	Antti Timperi, VTT Heikki Purhonen, LUT
Main Culture	Maintenance culture and management of change	1900	2002 - 2005	Teemu Reiman, VTT
SafetyManagement	Safety management in non-nuclear contexts with potential relevance for the nuclear power industry and regulators	720	2002 - 2005	Ola Svenson, Stockholm Univ
3DTransientSeminar	Seminar on 3D BWR Transient Analysis Methodology	280	2002 - 2003	Antti Daavittila, VTT

Acronym	Activity name	Total NKS funding kDKK 2002-2005	Duration	Leader(s)
BarriersControlManagement	Barriers, control and management - An analysis of concepts with applications in nuclear power plant safety	695	2002 - 2004	Morten Lind, DTU
RutheniumReleases	Ruthenium behaviour in severe accident condition	900	2002 -	Ari Auvinen, VTT
PreDeliMelt	DELImelt pre-project	180	2002	Bal Raj Sehgal, KTH
CCFModels	CCF model comparison	101	2002	Ralph Nyman, SKI
DigitalRequirements	Traceability and communication of requirements in digital I&C systems development, TACO	950	2002 - 2005	Terje Sivertsen, IFE Atoosa P-J Thunem, IFE
RiskInformedDecisions	Framework for systematic approach and documentation for risk-informed decision making, pre-project	100	2002	Kaisa Simola, VTT
Valdor2003	VALDOR 2003: the 3rd symposium addressing transparency in risk assessment and decision making	100	2002	Kjell Anderson, Karinta Konsult
AutomationSeminar	Nordic seminar on nuclear automation	118	2002	Karl-Erik Erikson, OKG
RegulatorySeminar	Nordic seminar on nuclear regulatory work on reactor safety	-	2003	Lars Gunsell, SKI
DecommSeminar	Nordic seminar on plant decommissioning	100	2004	Karin Brodén, Studsvik RadWaste AB
ShutdownSequences	Evaluation of reactor shutdown sequences with partly failing of shutdown systems	250	2004	Göran Hultqvist, Forsmarks Kraftgrupp
NOTNet	Nordic thermal-hydraulic and nuclear safety network	300	2004	Jari Tuunanen, VTT
ExCoolSE	In-vessel and ex-vessel coolability and energetics of steam explosions in boiling water reactors	800	2004 -	Hyun Sun Park, KTH
ImprovementPrgSeminar	Seminar on experience from Nordic safety improvement programs towards NPPs in Russia and Eastern European countries	100	2004	Thorbjörn Björlo, IFE
KnowledgeManagement	Workshop on knowledge management in Nordic NPPs	90	2004	Svein Nilsen, IFE
CorrosionFatigue	Corrosion fatigue	200	2005 -	Urpo Sarajärvi, VTT
CableAging	Wire system ageing assessment and condition monitoring	200	2005 -	Paolo Fantoni, IFE

Acronym	Activity name	Total NKS funding kDKK 2002-2005	Duration	Leader(s)
MORE	Management of requirements in NPP modernisation projects	150	2005 -	Terje Sivertsen, IFE Atoosa P-J Thunem, IFE
CostCalculation	Cost calculation and related issues with regard to decommissioning and dismantling of nuclear research facilities	200	2005 -	Rolf Sjöblom, Tekedo AB

1.1.2 NKS-R Funding

Annual NKS funding to NKS-R is shown in Figure 2. The total costs of the NKS-R program during 2002-2005 have been 11.7 MDKK, of which the activities have received 9.8 MDKK and the program manager 1.9 MDKK (16%). Funding of the program manager consists of the fees, program manager's travel costs and co-ordinating costs such as arranging internal seminars for the activity leaders.

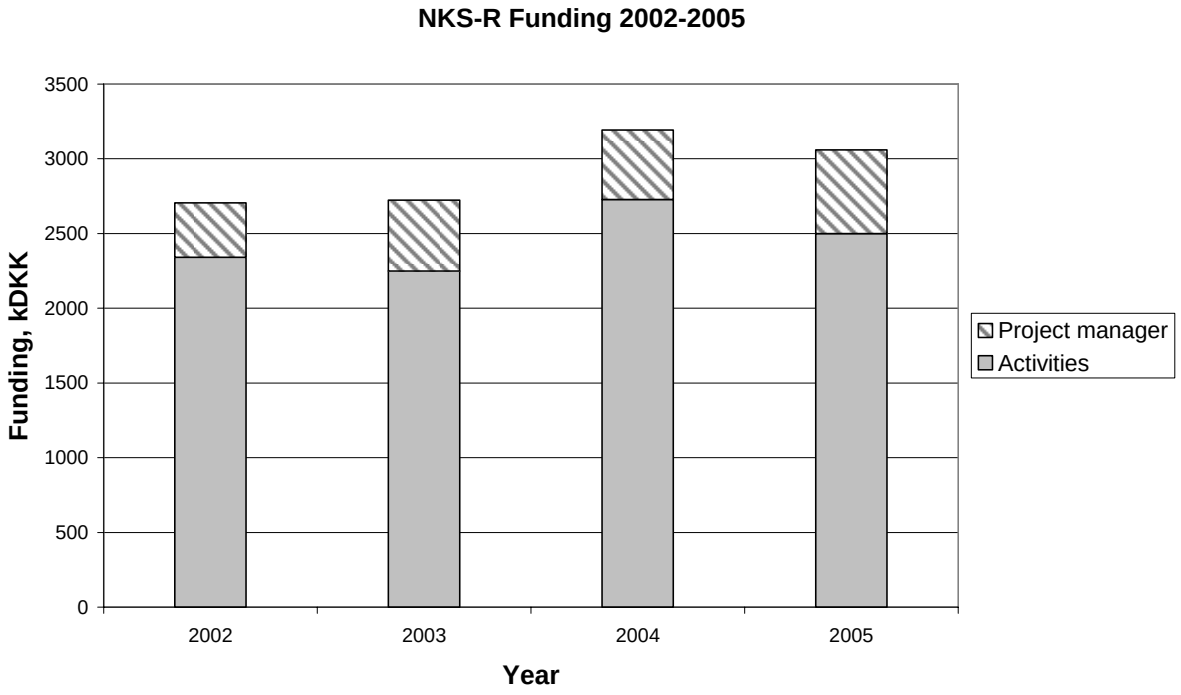


Figure 2. Annual NKS funding to NKS-R in 2002-2005, thousands of Danish kroner (kDKK).

NKS annual funding to individual activities has varied from about 0.1 to 0.6 MDKK. Research projects have usually received 0.3-0.4 MDKK annually, whereas a typical sum granted for arranging a seminar has been 0.1 MDKK. It must be pointed out that the NKS-R funding is not the main funding source for the activities. A majority of the resources is provided by national or other funding.

Of the 23 NKS-R activities, seven have received a substantial NKS funding, over 0.5MDKK, in 2002-2005:

- MainCulture (1.90 MDKK),
- DeliPool (1.385 MDKK),
- ExCoolSE (0.80 MDKK, PreDeliMelt 0.18 MDKK, in total 0.98 MDKK),
- DigitalRequirements (0.95 MDKK),
- RutheniumReleases (0.90 MDKK),
- SafetyManagement (0.72 MDKK) and
- BarriersControlManagement (0.695 MDKK).

All activities listed above were started in 2002 and were continued at least for three years.

Development of the NKS funding to the themes DELI and MANGAN, and to NKS-R seminars is shown in Figure 3. The numbers in the Figure show the year of the funding decision, which causes small inconsistency. For example, the funding decision for the decommissioning seminar was made in 2004, but the seminar was arranged in 2005. It is hence shown in the 2004 column.

Figure 3 illustrates the dynamic nature of the current NKS program structure. Focus on different themes has varied considerably during the evaluated period. Summing over the four years 2002-2005, both themes have received almost equal NKS funding (48% to Management and organisation, 44% to Development and validation). Total NKS-R funding for arranging of seminars has been 0.8 MDKK in 2002-2005, i.e. ~8%.

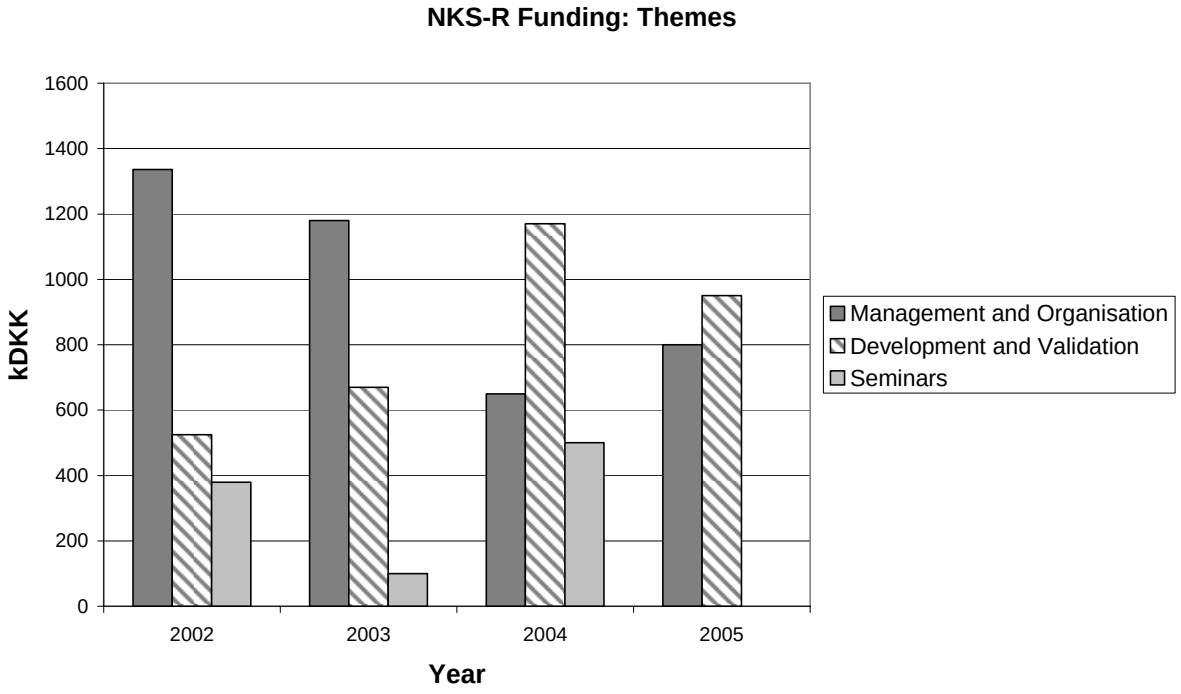


Figure 3. Distribution of NKS-R funding to activity themes and to seminars.

Funding distribution to research areas in 2002-2005 is shown in Figure 4. Two focus areas can be seen:

- thermal-hydraulics / severe accidents and
- organisational issues / safety culture,

which both have received approximately a third of the total. The remaining third has been allocated to the other five areas. The distribution reflects the history of the NKS-R program since 2002. Activities in the two larger were part of the program already in 2002 and have continued to 2005. Radioactive waste and decommissioning as well as plant lifetime management are newcomers to the program, having activities started in 2005.

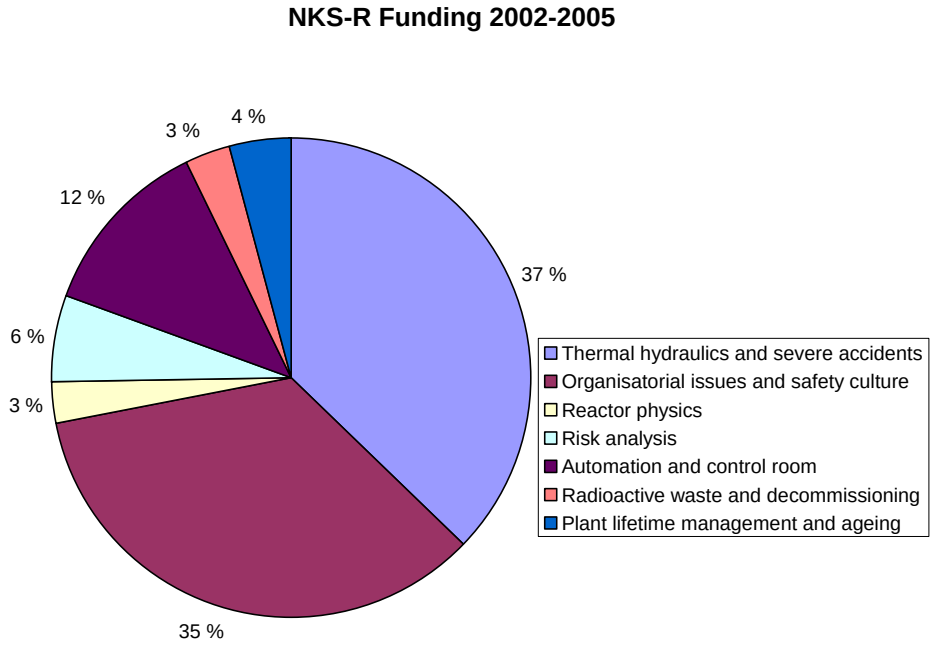


Figure 4. Distribution of NKS-R funding (total 2002-2005) to research areas.

Leading organisations of the NKS-R activities in 2002-2005 are listed in Table 3, which shows also the total NKS funding for their activities. There is a significant difference in organisation of nuclear safety research between the Nordic countries, illustrated also by the number of NKS-R activity leading organisations per country: Sweden had 8 organisations managing 10 activities, whereas the Finnish 7 activities have been managed by VTT, and the Norwegian 5 by IFE.

The activities managed by VTT have received by far the largest share of NKS-R funding in 2002-2005, about 45% of the total. The VTT led activities have in fact received a larger sum than the activities of the next four organisations (IFE, KTH, SU, DTU) together.

Table 3. NKS-R Funding to organisations. Thousands of DKK (kDKK). Total 2002-2005

Country	**Organisation**	**Number of activities**	**NKS funding to activities 2002-2005 (kDKK)**
Finland			
	VTT	6½	4372,5
	LUT[1)]	½	692,5

Country	Organisation	Number of activities	NKS funding to activities 2002-2005 (kDKK)
Sweden			
	SU	1	720
	KTH	2	980
	SKI	2	101
	Karinta Konsult	1	100
	OKG	1	118
	Studsvik	1	100
	RadWaste Forsmark	1	250
	Tekedo AB	1	200
Norway			
	IFE	5	1490
Denmark			
	DTU	1	695
Total		23	9819

[1)] Funding for the DeliPool activity has been equally divided between LUT and VTT

The total funding received in 2002-2005 grouped by the country of the leading organisation is shown in Figure 5. Finnish (VTT) led activities have received 52% of the NKS-R funding, Swedish 27%, Norwegian 13% and Danish 7%. The pattern has remained approximately the same also in funding decisions for 2006 activities.

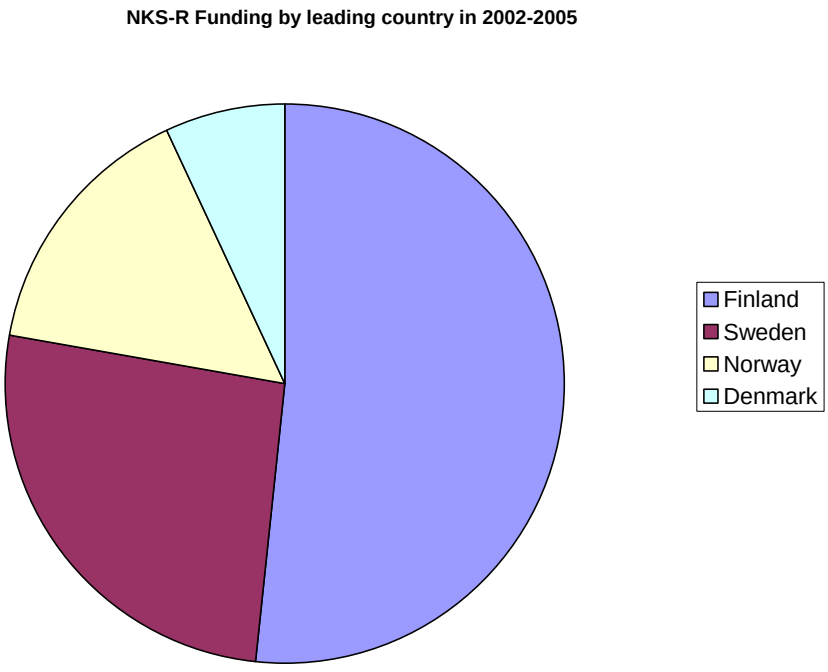


Figure 5. NKS-R Funding in 2002-2005 per country of the leading organisation.

Considering the size of the reactor safety programs in the Nordic countries, Swedish activities have obviously been underrepresented in NKS-R.

1.1.3 NKS-R publications

NKS-R publication activity has been prolific. 28 reports have been published in the NKS publication series alone, listed in Table 4. In addition, numerous reports have been published in scientific journals, at conferences and as national research publications.

Table 4. Summary of NKS-R publications in the NKS series, 2002-2005

Activity name and acronym	**Project publications in NKS series**
Condensation pool experiments (PrePool & DeliPool)	A. Timperi *et al.*: *Numerical analyses of a water pool under loadings caused by a condensation induced water hammer.* NKS-96. Mar 2004
	J. Laine, M. Puustinen: *Preliminary condensation pool experiments with steam using DN80 and DN100 blowdown pipes.* NKS-97. Mar 2004
	Timo Pättikangas et al*: Fluid-Structure Interaction Analysis of a Water Pool under Loading Caused by a Condensation-Induced Water Hammer.* NKS-104. Apr 2005
	J. Laine & M. Puustinen: *Condensation Pool Experiments with Steam Using DN200 Blowdown Pipe.* NKS-111 Aug 2005
Maintenance culture and management of change (Main Culture)	T. Reiman *et al.*: *Contextual assessment of maintenance culture at Olkiluoto and Forsmark.* NKS-94 Apr 2004
	Teemu Reiman et al: *Maintenance culture and management of change. - Intermediate report 2004.* NKS-108 Apr 2005
Safety management in non-nuclear contexts with potential relevance for the nuclear power industry and regulators (SafetyManagement)	O. Svenson, I. Salo: *Safety Management: A Frame of Reference for Studies of Nuclear Power Safety Management and Case Studies from Non-Nuclear Contexts.* NKS-88 Sep 2003
	O. Svenson, I. Salo, P. Allwin: *On safety management and nuclear safety.* NKS-95 Mar 2004
	Ilkka Salo and Ola Svenson (Coordinators)*: A summary of the Nordic-group conference on safety management, Lund, Sweden, October 28-29, 2004.* NKS-106 Apr 2005
Seminar on 3D BWR Transient Analysis Methodology (3DTransientSeminar)	A. Daavittila (ed.): *3D Analysis Methods - Study and Seminar.* NKS-89 Oct 2003
Barriers, control and management - An analysis of concepts with applications in nuclear power plant safety (BarriersControlManagement)	M. Lind: *Barriers, Control and Management. Report from the pilot phase.* NKS-87 Sep 2003
	Johannes Petersen: *Countermeasures and Barriers* NKS-113 Oct 2005
	Morten Lind: *Modeling Goals and Functions of Control and Safety Systems -theoretical foundations and extensions of MFM.* NKS-114 Oct 2005
Ruthenium behaviour in severe accident condition (RutheniumReleases)	U. Backman *et al.*: *Ruthenium behaviour in severe nuclear accident conditions - progress report.* NKS-92 Mar 2004
	U. Backman *et al.*: *Ruthenium Behaviour in Severe Nuclear Accident Conditions - Final Report.* NKS-100 Aug 2004
DELImelt pre-project (PreDeliMelt)	B.R. Sehgal, H.S. Park: *Final Report on PRE-DELI-MELT, Pre-Project (PRE) on Development & Validation (DELI) of Melt Behavior (MELT) in Severe Accidents.* NKS-99 Jun 2004
CCF model comparison (CCFModels)	U. Pulkkinen: *CCF Model Comparison.* NKS-90 Apr 2004
Traceability and communication of	T. Sivertsen *et al.*: *Traceability and Communication of Requirements in Digital I&C Systems Development. Project Report 2003.* NKS-91 Mar 2004

Activity name and acronym	Project publications in NKS series
requirements in digital I&C systems development, TACO (DigitalRequirements)	Terje Sivertsen et al*: Traceability and Communication of Requirements in Digital I&C Systems Development - Project Report 2004.* NKS-103 Apr 2005
	Terje Sivertsen et al: *Traceability and Communication of Requirements in Digital I&C Systems Development. Final Report.* NKS-115 Oct 2005
Framework for systematic approach and documentation for risk-informed decision making, pre-project (RiskInformedDecisions)	K. Simola, U. Pulkkinen: *Risk Informed Decision Making – a Pre-Study.* NKS-93 Apr 2004
VALDOR 2003: the 3rd symposium addressing transparency in risk assessment and decision making (Valdor2003)	K. Andersson (ed.): *VALDOR 2003. VALues in Decisions On Risk. Proceedings.* Jun 2003
Nordic seminar on nuclear automation (AutomationSeminar)	K-E Eriksson (ed.): *Proceedings of the Nordic Seminar on Nuclear Automation.* NKS-101 Aug 2004
Nordic seminar on plant decommissioning (DecommSeminar)	Karin Brodén (ed.): *Seminarium om avveckling. Risø, 13-15 September 2005.* NKS-116 Dec 2005.
Nordic thermal-hydraulic and nuclear safety network (NOTNet)	Jari Tuunanen and Minna Tuomainen*: Final Report of the "Nordic Thermal-Hydraulic and Safety Network (NOTNET)"- Project.* NKS-107 Apr 2005
In-vessel and ex-vessel coolability and energetics of steam explosions in boiling water reactors (ExCoolSE)	H. S. Park et al: *Ex-Vessel Coolability and Energetics of Steam Explosions in Nordic Light Water Reactors - EXCOOLSE Project Report 2004* NKS-112 Oct 2005
Seminar on experience from Nordic safety improvement programs towards NPPs in Russia and Eastern European countries (ImprovementPrgSeminar)	Thorbjörn Björlo (ed.)*: Nordic Nuclear Safety Research (NKS) Seminar on "Experience from Nordic Safety Improvement Programmes towards Nuclear Power Plants in Russia, Central- and East-European Countries" Park Hotel, Halden, Norway 25th-26th November, 2004. - Seminar proceedings.* NKS-105 Apr 2005
Workshop on knowledge management in Nordic NPPs (KnowledgeManagement)	Svein Nilsen: *Knowledge Management in Nordic NPPs. Summary report of the findings from the workshop.* NKS-102 Apr 2005

1.1.4 NKS-R Seminars

Nine seminars have been arranged by NKS-R during 2002-2005.

- 3D BWR Transient Analysis Methodology April 8, 2003, Otaniemi, Finland.
- Values in Decisions on Risk, VALDOR 2003, June 9-13, 2003, Stockholm, Sweden.
- Nordic Seminar on Nuclear Regulatory Work on Reactor Safety, November 3-4, 2003, Stockholm, Sweden.
- Nordic Seminar on Nuclear Automation, April 5-7, 2004, Oskarshamn, Sweden
- Knowledge management in Nordic NPPS's, October 7-8, 2004, Halden, Norway
- Nordic-group conference on safety management, October 28-29, 2004, Lund, Sweden
- NKS Seminar on Safety Improvement Programs in Russia and Eastern Europe, November 25 - 26, 2004, Halden, Norway
- Traceability and Communication of Requirements in Digital I&C Systems Development, 2nd TACO Industrial Seminar, December 8, 2004, Helsinki, Finland
- Decommissioning Seminar, September 13-15, 2005, Risø, Denmark

The seminar participants have considered the NKS-R seminar activity useful.

1.2 Evaluation methods

Evaluation of the NKS-R part was conducted by Per Persson and Risto Sairanen. When assigning the evaluation task, the NKS Board determined a set of evaluation criteria. The criteria were formulated by the evaluators as a list of questions shown in Table 5. Information to answer the questions was collected from three sources.

- interviews of selected persons from Finland and Sweden
- a survey sent to NKS-R research result end-users and to the project participants
- review work by the evaluators

The source used for a particular question is indicated in Table 5.

Table 5. The criteria used in the NKS-R 2002-2005 evaluation

No	Question	Source of information		
		Interview	Survey	Review
1	How well is the NKS-R research program known?	✓	✓	
2	To what extent are the results utilised?	✓	✓	
3	How useful have the NKS-R seminars been?	✓	✓	
4	Has the NKS-R program created and maintained Nordic networks in reactor safety?	✓	✓	
5	Has the NKS-R program built new competence or transferred competence within the Nordic countries?	✓	✓	✓
6	Has the program provided possibilities for young scientists?	✓	✓	✓
7	What has been the scientific level?	✓	✓	✓
8	Has the program been balanced? Especially, • Have important organisations been involved? • Have there been enough information spreading activities in form of seminars, etc?	✓	✓	
9	Are the priorities the correct ones? Are any important activities missing?	✓	✓	
10	How relevant are the proposal evaluation criteria?	✓		
11	Did the projects that were selected for funding have clear goals? Did the project leaders follow the project plans and timetables?	✓		✓
12	Has the program been conducted in a cost-effective way?	✓		✓
13	What are the positive and negative experiences from the NKS-R 2002-2005 work?	✓		
14	Is the overall quality of the results satisfactory	✓		✓
15	What are recommendations for future work?	✓	✓	✓

1.2.1 Interviews

The objective of the personal interviews was to get information that would be impossible to obtain by other means. Important persons in this respect were the former and current program managers. Questions 10 and 11, for example, are of the type for which the program managers have much more background information and experience than others.

The persons interviewed in Finland were:

Petra Lundström, Fortum,	former NKS-R program manager
Nici Bergroth, Fortum	former NKS-R program manager
Jorma Aurela, Ministry of Trade and Industry	owner representative, NKS board member
Heikki Raumolin, Fortum	NKS board member
Ulla Ehrnstén, VTT	NKS board member
Olli Vilkamo, STUK	former NKS board member

In addition, Timo Okkonen, a former NKS-R program manager sent written comments to the questions.

The Swedish persons interviewed were:

Jesper Kierkegaard, Vattenfall	current NKS-R program manager
Karl-Fredrik Ingemarsson, Vattenfall	NKS board member
H. S. Park, KTH	NKS-R activity leader (ExCoolSE)
Ola Svensson, Stockholm University	NKS-R activity leader (SafetyManagement)
Lars Gunsell, SKI	owner representative, NKS board member

The interviews were documented in summary reports that were sent for comments and approval to the interviewed persons.

1.2.2 Opinion survey

Information from the end-users and activity participants was collected by a web-based opinion survey. The question sheet used in the survey is shown in Appendix 1. The survey was sent to 41 addressees in the following 22 organisations. The response was moderate, 15 answers from 10 organisations were received by May 5 2006, when the survey page was closed.

Table 6. Distribution of the NKS-R questionnaire

Organisation	**Number of answers**
Denmark	
Beredskabsstyrelsen	-
Forskningscenter Risø	-
Danish Radiation Protection Institute, SIS	-
Danish Decommissioning, DD	-
Ørsted DTU	-
Finland	
Ministry of Trade and Industry	1
Radiation and Nuclear Safety Authority	3
Teollisuuden Voima Oy	1
Fortum	1
Technical Research Centre of Finland	-
Lappeenranta University of Technology	-
Posiva Oy	-
Iceland	
Geislavarnir ríkisins	-
Norway	
Statens strålevern	2
Institutt for Energiteknikk	1
Sweden	
Vattenfall AB	1
SwedPower AB	-
Kärnkraftsäkerhet och Utbildning AB, KSU	-
Ringhals AB	-
OKG AB	1
Forsmarks Kraftgrupp	2
Statens Kärnkraftinspektion	2

1.2.3 Evaluator reviews

A third source of information was review of selected NKS-R activities by the evaluators themselves or by persons from the Finnish and Swedish regulatory organisations. Activity reports published in the NKS series were the main source of information.

The objective of the reviews was to assess the scientific level of the activity reports, connections to international research, the value of the results to the end users, and the overall quality of the results. The eight NKS-R activities that had received the largest NKS funding in 2002-2005 were reviewed in this way. They are listed in Table 7.

Table 7. NKS-R activities selected for evaluator review

Activity name (Acronym)	Leading organisation	Reports reviewed
Maintenance culture and management of change (Main Culture)	VTT	NKS-108
Condensation pool experiments (DeliPool)	VTT	NKS-104
In-vessel and ex-vessel coolability and energetics of steam explosions in boiling water reactors (ExCoolSE)	KTH	NKS-112
Traceability and communication of requirements in digital I&C systems development, TACO (DigitalRequirements)	IFE	NKS-91, NKS-103, NKS-115
Ruthenium behaviour in severe accident condition (RutheniumReleases)	VTT	NKS-92, NKS-100, NKS-118
Safety management in non-nuclear contexts with potential relevance for the nuclear power industry and regulators (SafetyManagement)	Stockholm University	NKS-88, NKS-95
Barriers, control and management - An analysis of concepts with applications in nuclear power plant safety (BarriersControlManagement)	Ørsted DTU	NKS-87, NKS-113, NKS-114
Nordic thermal-hydraulic and nuclear safety network (NOTNet)	VTT	NKS-107

1.3 NKS-R Evaluation results: The survey and the interviews

Information from the survey answers and from the interviews is collected and summarised here under the criteria from Table 5.

1.3.1 How well is the NKS-R research program known?

The question was asked in the survey in a numerical form using 5 as the highest, and 1 as the lowest score. The fractional distribution of the results is shown in Fig. 5.

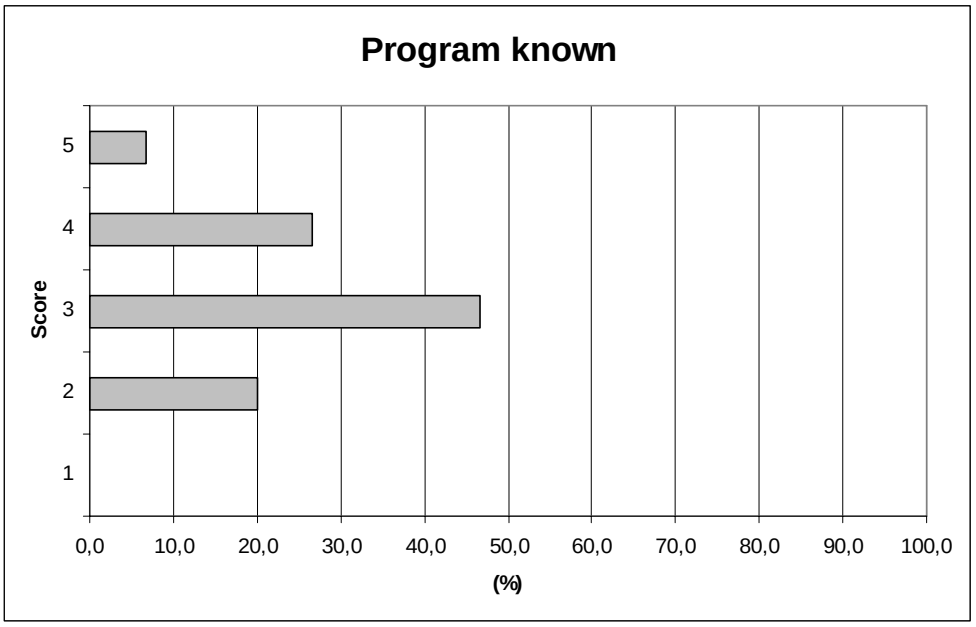


Figure 6. Survey results: familiarity of the NKS-R program.

The result indicates that the program is quite well known, at least within those organisations and by the persons who answered the survey. A remark was added in one question, that in his organisation the program is well known within a small group of people, but most of the persons working in the organisation did actually know very little of the NKS programs. Similar opinions were also given from some interviewed persons.

1.3.2 To what extent are the results utilised?

The numerical results given in the survey are shown in Figure 7. There is considerable spread, but the overall score is fairly good. It was pointed out in interviews and in the comments given in the survey, that the NKS-R activities normally are part of a larger entity, for example part of a national research project. Utilisation of results is usually an important criterion for national research. By complementing the national or international project, the NKS-R results become useful at least for some end users.

Utility representatives pointed out that in order to ensure that the results are in a form that they can use, the utilities should be involved in the activities from early stage. Strong connection to the needs of power plants was recommended.

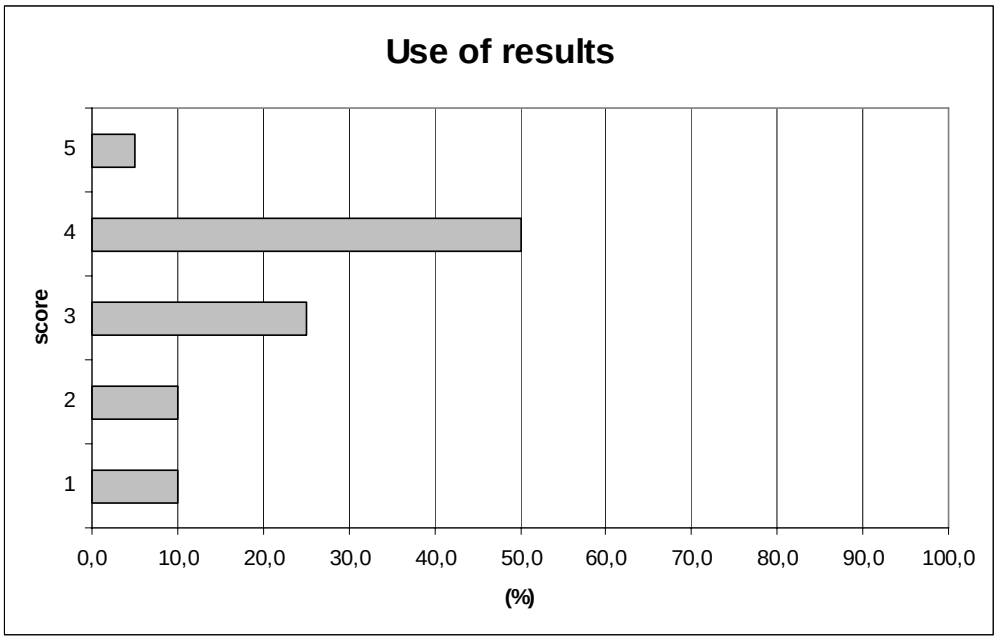


Figure 7. Survey results: Utilisation of the NKS-R program results.

1.3.3 How useful have the NKS-R seminars been?

From interviews and from the survey results it is obvious that arrangement of seminars is a very important form of NKS activity. The seminars could cover one specific subject or several minor topics. In this way there is an active distribution of the research results and there is a possibility to meet experts and to generate discussions.

The NKS-R seminars have undoubtedly been successful. Nine seminars have been arranged within four years. The survey scores were all high numbers 3-5, averaging over 4. During interviews, the Automation seminar in Oskarshamn, the seminar on Nuclear Regulatory Work in Stockholm, and the Decommissioning seminar in Risø were mentioned as examples of useful and well organised NKS-R seminars.

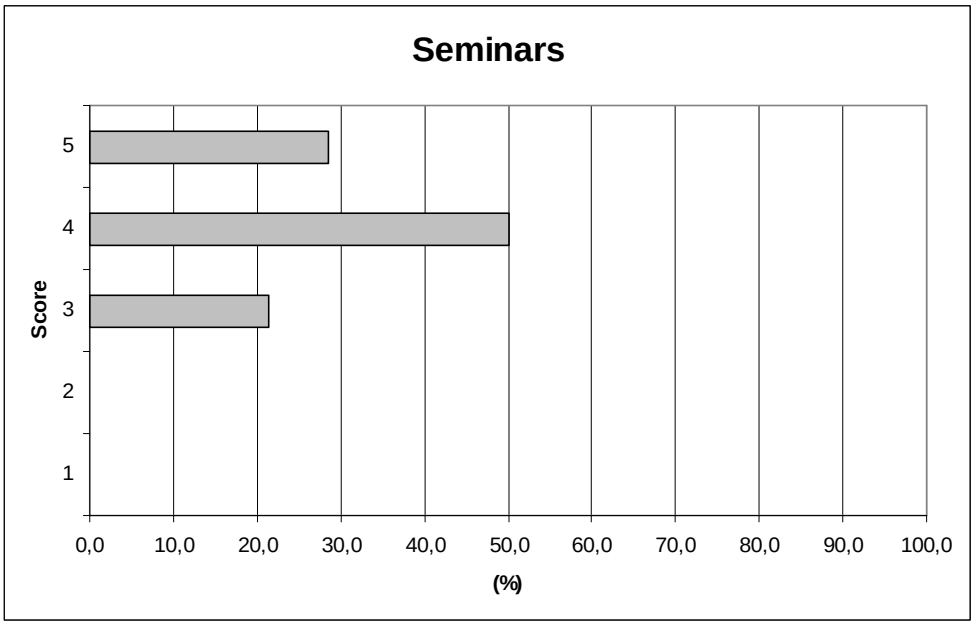


Figure 8. Survey results: NKS-R seminars.

The seminars up to date have focused on a specific topic, not on NKS-R research. There has been no general NKS-R seminar to give information of the total program results in 2002-2005. It was recommended to arrange also this kind of seminars at certain intervals. A 4-year interval was considered suitable, because enough results should be available to arrange a seminar.

Some internal seminars for NKS-R activity leaders have also been arranged. The persons who actively participated in the program (managers, activity leaders) considered this type of joint discussion necessary for effective conduction of the program.

1.3.4 Has the NKS-R program created and maintained Nordic networks in reactor safety?

The question on Nordic networks received maybe the most complex response in the list of questions The numerical results for the question were fairly good, as shown in Figure 9. Criticism was expressed in the written comments, however. It was pointed out that there had been a lack of contacts to the established Nordic co-operation groups like NPSAG, NORTHNET or APRI.

In most of the NKS-R activities the main work has been conducted by the leading organisation alone. An indication of this can be seen in the reporting. Only two of the NKS-R activities have produced reporting having authors from more than one country.

There have been cases, where networking has undoubtedly been good. MaintenanceCulture and DigitalRequirements were mentioned in interviews as successful examples of network building activities. Indicative, these are the NKS-R projects that have produced reports by authors from several countries.

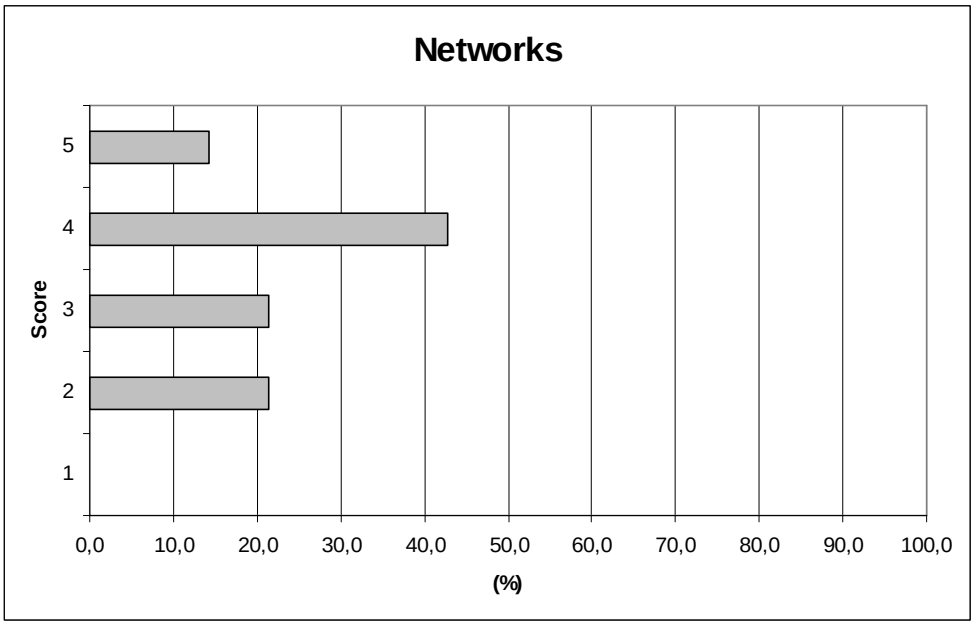


Figure 9. Survey results: Network creation.

It was recommended in one survey answer that to improve the co-operation each NKS-R research activity should have participants from at least two Nordic countries. Another suggestion was that a mechanism could be established, by which the program manager could merge activity proposals having similar contents into one joint activity.

There has been an activity in NKS-R with a particular objective to create a Nordic network, NOTNet. NOTNet produced a plan for Nordic thermal hydraulic and safety network, including detailed research plans. The next step has been taken late 2005 with the NORTHNET kick-off meeting. The new NORTHNET co-operation is separate from NKS. It could be considered to include NORTHNET supporting or co-ordinating activities in the future NKS-R, too.

1.3.5 Has the NKS-R program built new competence or transferred competence within the Nordic countries?

The numerical survey results, as shown in Figure 10, are again good. It was pointed out, that the NKS-R research has been linked to the national research programs having as one objective to build new competence. In most cases, it is impossible to separate the NKS-R part from the nationally funded part.

It was stressed in the interviews that the development of competence is an important factor for the Nordic countries. It was suggested that organized education, as a series of seminars and/or regular education in relevant subjects might be an activity supported by NKS. In such an activity the research results could be presented and explained together with more fundamental information. Possibly, existing Nordic facilities could be used, like research reactors and full scale simulators.

The question is linked to the next question on the possibilities for young scientists.

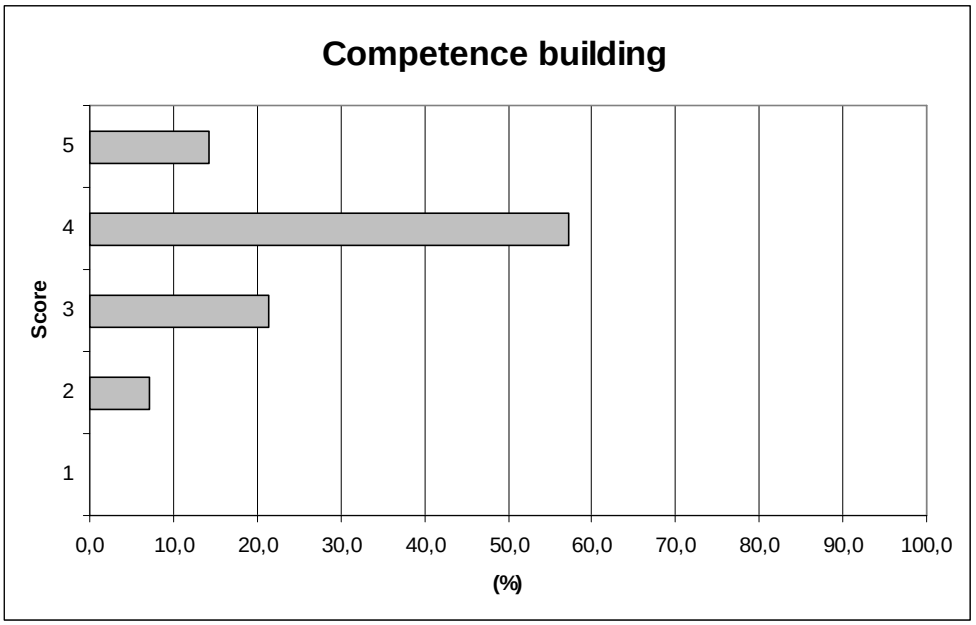


Figure 10. Survey results: Competence building.

1.3.6 Has the program provided possibilities for young scientists?

The score in the survey was quite good also in this respect. Participation of young scientists is one of the evaluation criteria for applications. Therefore it has been considered in most of the activities. On the other hand, the program has not been targeted at young persons. Most of the activity leaders have been experienced scientists.

The generation shift is a concern for all Nordic countries. In Finland and Sweden the generation who participated in the building of existing reactors is retiring within some years. In was suggested that NKS could initiate some activity focused especially on young scientists.

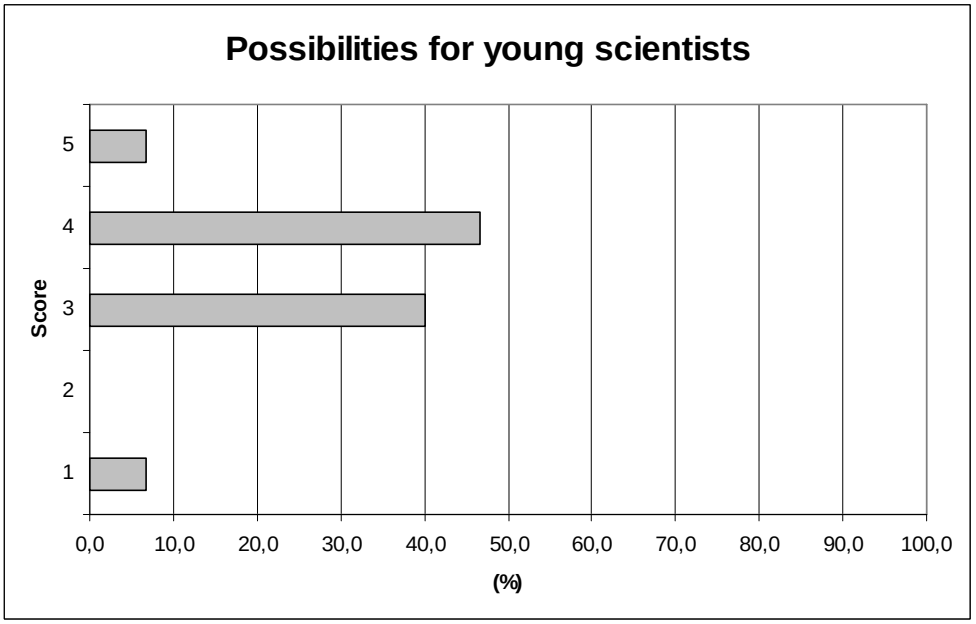


Figure 11. Survey results: Possibilities for young scientists.

1.3.7 What has been the scientific level?

The survey results gave rather good scores on this question. The interviewed persons considered the scientific level high in the areas they were familiar with. Of the projects that have received the highest NKS-R financing, many have produced results of high scientific quality. Some examples mentioned in this respect were: DeliPool, ExCoolSE, MainCulture, RutheniumReleases and DigitalRequirements.

There was also a recommendation to encourage some visionary work, even if it does not produce immediate results.

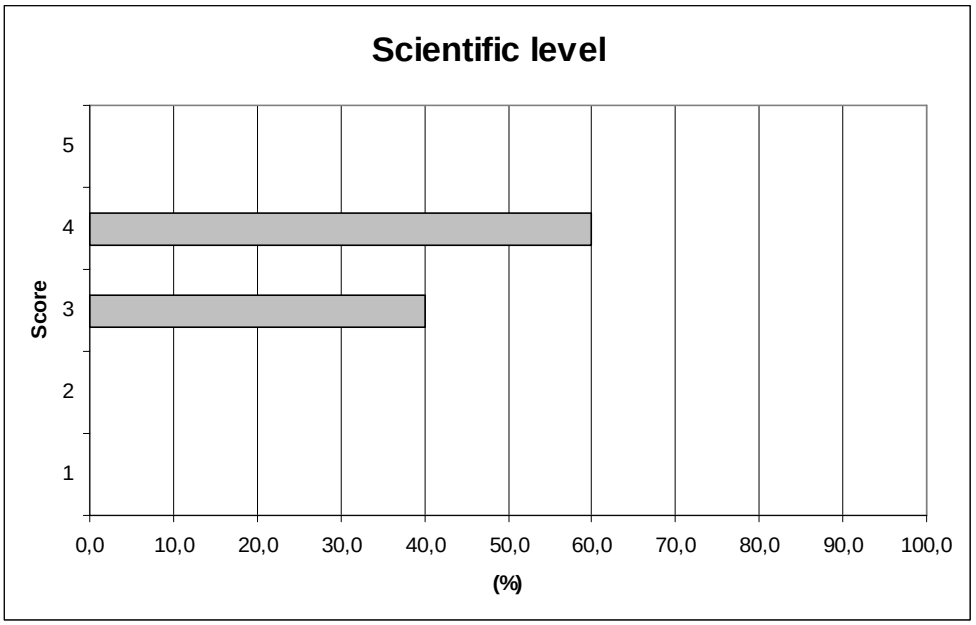


Figure 12. Survey results: NKS-R scientific level.

1.3.8 Has the program been balanced?

Written comments were given on this topic in the survey questionnaire. The balance of the NKS-R research topics and the themes was considered relatively good by the persons that answered the survey. The interviewed persons were also satisfied with the balance.

An increase in seminar activity and information meetings was requested in several answers. On the other hand, it was pointed out that there is a limit to the frequency of seminars that would be attended, and that there should be a need for a Nordic seminar. It must be pointed out, that the current NKS method of working has decreased the direct influence of the governing bodies. A seminar will be arranged only if some organisation submits a proposal for it. The program manager can influence proposals in an indirect way by contacting suitable organisations and encouraging project proposals for seminars. The Board can also play an active role within their own country.

The current NKS organisation allows for dynamics, as the annual evolution of the NKS-R themes shows in Fig. 2. Eventually, the content of the program is based on the activity proposals. For

example, automation and plant ageing are topics that could have had more weight but applications in these areas have been few up to recent years. The weight of decommissioning is increasing, which was generally considered positive.

Most of the activity proposals came from universities and research organisations. The utilities have been involved in the activities but have not acted as activity leaders except in a few cases. It was pointed out, that utility involvement was necessary for rendering the results applicable at the power plants. Without direct power plant contacts, the research was easily considered "academic" by the end users, and not relevant for practical application.

1.3.9 Are the priorities the correct ones? Are any important activities missing?

The NKS-R instructions for Call for Proposals do not rank the research topics. Some interviewed persons considered that NKS should specify the research objectives more precisely. More weight should be put on the applicability of the result by defining the end users and discussing with them in advance, before submitting a proposal.

It was also admitted that a small program can not cover everything. On particular topics, the response varied widely between the answers. Some examples are:

- Decommissioning is an interesting new opening
- More waste issues
- Waste issues are not important
- Modernisation of I&C should have a higher volume
- More PSA
- Keep organisation and human factors in focus
- Focus on nuclear specific issues
- More projects on safety assessment of design and operation
- There is a good balance now, which should be kept in the future

It was mentioned in one of the interviews, that the NKS program should not give an impression that the current structure (the projects themselves, types of projects, research topics) will continue unchanged for ever. It was therefore recommended, that NKS reviews the whole program at certain intervals and changes the structure if considered appropriate.

1.3.10 How relevant are the proposal evaluation criteria?

This question was only put to persons, who have been involved with the activity proposals, i.e. the program managers and activity leaders. They were generally satisfied with the present application process and the evaluation criteria. The NKS-R framework report has been revised a couple of times with improvements. It was considered that the current criteria reflect well the objectives of the NKS-R program.

A common practise in EU research projects is that the participating organisations must come from several EU countries. This is not required in NKS-R considering individual activities. The overall program should be geographically balanced, but ensuring this has been left to the program managers and to the NKS board.

As an evaluation criterion, the term “Nordic dimension” has been applied. The term has enabled funding of activities conducted by single countries, even by single organisations, if the activity topic has been of common Nordic interest. All the reviewed NKS-R activities have fulfilled this, quite flexible, evaluation criterion. Even if the research has been conducted by a single organisation, the results have been applicable for more than one country.

1.3.11 Did the projects that were selected for funding have clear goals? Did the project leaders follow the project plans and timetables?

The question was put to the program mangers. They considered the quality of the projects good and managing of the NKS-R program relatively problem free. Generally, the activity leaders kept the schedules and budgets. In those few cases, where a delay in reporting was observed, funding has been frozen until the missing document has been delivered.

1.3.12 Has the program been conducted in a cost-effective way?

This question was asked in the interviews but not in the survey. The main comment was that NKS-R has produced good results with a small budget. The cost basis of the activity proposals has been regularly checked, and the costs have been acceptable.

Program management requires a large effort. The former project managers considered that the work can not be done with less than the volume they have used, 50% of their working hours. They recommended that the NKS Board should take a more active role in reviewing the applications and discussing the program manager background information paper.

NKS-R funding is given in two rounds: a larger sum is distributed in autumn; a part is reserved for distribution in spring. The former NKS-R program managers considered the spring round unnecessary. Their opinion was that it complicates the project proposal evaluation and conduction of the program. The main body of activities receives financing in the autumn, starts work at the beginning of the next year and can provide measurable results within the same year. The projects with a funding decision in May make contracts early summer and generally begin their work only after the summer vacations. The results they have produced by the end of the year are therefore very limited.

The end users pointed out that all NKS-R program managers have been effective, but that the system is also quite dependent on the capability of the program manager. Some of them also felt that NKS organisation is heavy considering the volume of the program.

1.3.13 What are the positive and negative experiences from the NKS-R 2002-2005 work?

During the interviews this question was put to the program mangers and activity leaders. The former program managers considered their work interesting, a good opportunity to learn of different research topics, and a valuable way to meet persons working in nuclear safety on Nordic countries. Before their assignment their impression of the NKS research had been vague, but their appreciation of the value of the NKS activities increased during the work. The method of working was considered generally efficient.

Two activity leaders were interviewed who both had NKS-R funding as complement to other funding sources. The ExCoolSE activity belonging to the DELI part did not have any participants from other countries whereas the SafetyManagement activity in MANGAN had participants from Finland and Norway. Both leaders had a positive experience of cooperation with NKS.

Concerning the experimental ExCoolSE project it was stressed that it is difficult to get funding for projects to such an extent that a ”critical mass” can be obtained and ”real research” can be carried out.

1.3.14 What are recommendations for future work?

Most of the survey results and interviews were positive with regard to the present NKS-R program. There are some comments, however, that were mentioned several times:

- efforts should be made to get a better distribution of the NKS-R activities and research results,
- a strong connection to the needs of power plants is needed,
- the work should be connected to the established Nordic working groups, as well as with EU-research,
- Nordic co-operation within activities should be better,
- a review every 4 or 5 years is needed

1.4 Detailed review of selected activities

The eight NKS-R activities that had received the largest NKS funding in 2002-2005 were reviewed by the evaluators and by persons from the Finnish and Swedish regulatory organisations. Activity reports published in the NKS series were the main source of information.

1.4.1 BWR condensation pool experiments

Title	**Condensation pool experiments**
Identification number and Acronym	NKS_R_2002_01, PrePool/DeliPool
Duration	Started 2002, continues in 2006
NKS funding 2002-2005	1.385 MDKK
Leader	Antti Timperi, VTT (FI)
Participants	VTT (FI), LUT (FI)
Deliverables	A. Timperi et al.: Numerical analyses of a water pool under loadings caused by a condensation induced water hammer. NKS-96, March 2004. J. Laine, M. Puustinen: Preliminary condensation pool experiments with steam using DN80 and DN100 blowdown pipes. NKS-97, March 2004. Timo Pättikangas et al: Fluid-Structure Interaction Analysis of a Water Pool under Loading Caused by a Condensation-Induced Water Hammer. NKS-104, April 2005. J. Laine & M. Puustinen: Condensation Pool Experiments with Steam Using DN200 Blowdown Pipe. NKS-111, August 2005.
Evaluated deliverables	NKS-104

BWR suppression pool studies were started in 2002 by a pre-project PrePool and later continued with the DeliPool activity. VTT has been the leading organisation. The activity includes

experiments (POOLEX) conducted at LUT and analyses of the experiments done at VTT. During the time under review, 2002-2005, PrePool/DeliPool has received 1.385 MDKK total NKS funding. In addition, the national funding to the project has been substantial.

Connections to other Nordic organisations have been few. No organisations outside Finland have participated. The Nordic dimension criterion has been justified by the objective of the investigation, which is common and judged important for all Nordic BWRs. By the end of 2005, the activity has published four reports in the NKS series.

The recent report *Fluid-Structure Interaction Analysis of a Water Pool under Loading Caused by a Condensation-Induced Water Hammer, NKS-104,* contains a description of a fluid-structure interaction analysis of a water pool caused by condensation induced water hammer. Advanced CFD and structural analysis codes have been used and the need for coupling such methods is emphasized. So called smart methods have been applied to couple commonly used codes from the two areas.

Three different methods for estimation of pressure loads in a pool from steam condensation have been tried. In one a Method of Images method based on POOLEX experiments was used to estimate chugging loads. The second was based on a homogeneous two-phase model for the CFD-application. In the third method the loads because of collapse of a circular cavity at constant pressure in an incompressible liquid (Rayleigh bubble) were evaluated. The situation was modelled as a mass sink based on the velocity of the bubble radius. The second part of the report was devoted to application of fluid-structure interaction code making use of Star-CD and ABAQUS FE.

The study had the character of testing the applicability rather than revealing more in-depth results. The objectives with the study were not clear and conclusions were rather vague. It was stated that the method of images was successfully applied but that the source term would need to be developed. The homogeneous method was inadequate. It was only stated that the loads of the collapsing bubble had been compared to previous calculations.

It appears that the objectives and results of the study are rather limited. Conclusions are based on experience with the numerical performance rather than the ability to simulate the physics of fluid-structure interaction. The study would have benefited from more extended comparisons with experiments or analytical solutions. The scientific content is judged as moderate. It needs to be significantly extended to be useful.

In the conclusions some pool wall displacement results were judged to be unrealistic. This was coupled to the limited degree of freedom. This and other conclusions would need a stronger substantiation and quantification to be useful. In the conclusions a reference is made to a previous analysis of a PWR core barrel during LOCA. No comments are made to potential relevance for this study.

1.4.2 Assessment of maintenance culture safety and efficiency in Finland and Sweden

Title	**Maintenance culture and management of change**
Identification number and Acronym	NKS_R 2002_02, MainCulture
Duration	2002-2005
NKS funding 2002-2005	1.9 MDKK
Leader	Teemu Reiman, VTT (FI)

Participants	VTT (FI), Mälardalen University (S)
Deliverables	T. Reiman et al.: Contextual assessment of maintenance culture at Olkiluoto and Forsmark. NKS-94, April 2004 Teemu Reiman et al: Maintenance culture and management of change. - Intermediate report 2004. NKS-108, April 2005
Evaluated deliverables	NKS-108

MainCulture, Contextual assessment of maintenance culture safety and efficiency in Finland and Sweden, was started in 2002 and continued until the end of 2005. VTT has been the leading organisation. Of all NKS-R activities, MainCulture has received the highest NKS funding in 2002-2005: 1.9 MDKK.

There has been an essential Nordic dimension in the activity. A network has been created between the researchers at VTT and MU. Distribution of competence has been done by a common research methodology created in the study and by the use of case studies from both Finland and Sweden. The activity reports have been jointly written by VTT and MU personnel.

The project has a considerable new value with regard to the organizational changes which have been made during later years at Swedish and Finnish nuclear power plants as a consequence of the deregulation of the electric power market. The activity has published two reports in NKS series during 2002-2005, and then the final one in 2006. The report *Maintenance culture and management of changes- Intermediate report 2004, NKS-108* has been used as basis of the NKS-R evaluation. This study is unique since it is the only one which has studied the consequences of changes in the nuclear field in a systematic way. The nuclear power industry in Sweden has learnt a lot of its major organisational changes during recent years, especially by follow ups/evaluations and the by improving routines and ways of working.

It has been judged that there is a substantial use of the study both by the plants and by the authorities because of creation of deepened knowledge. The study emphasises important factors which should be considered when organizational changes are to be done in a safe way.

The researchers, especially at VTT, are young and are in the beginning of their careers.

1.4.3 Safety Management

Title	**Safety management**
Identification number and Acronym	NKS_R_ 2002_04, SafetyManagement.
Duration	2002-2005
NKS funding 2002-2005	0.72 MDKK
Leader	Ola Svenson, Stockholm University
Participants	SU (S), Lund University (S), IFE (NO), VTT (FI)

Deliverables	O. Svenson, I. Salo: Safety Management: A Frame of Reference for Studies of Nuclear Power Safety Management and Case Studies from Non-Nuclear Contexts. NKS-88, September 2003 O. Svenson, I. Salo, P. Allwin: On safety management and nuclear safety. NKS-95, March 2004 Ilkka Salo and Ola Svenson (Coordinators): A summary of the Nordic-group conference on safety management, Lund, Sweden, October 28-29, 2004. NKS-106, April 2005 Seminar: Nordic-group conference on safety management, October 28-29, 2004, Lund, Sweden
Evaluated deliverables	NKS-88, NKS-95

The objectives of SafetyManagement were first to create a theoretical framework, to use this framework for analyses of non-nuclear industries, and to investigate the potential relevance of the results for the nuclear power industry and nuclear regulators The purpose of this activity was also to exchange knowledge between researchers in Nordic countries in the field of safety management and safety culture. SafetyManagement was conducted in 2002-2005 and received from NKS 0.72 MDKK funding during that time.

Stockholm University was the leading organisation. The activity had an essential Nordic dimension because it created a network between researchers from VTT, Lund University, Stockholm University and the Halden project Group. The network has arranged meetings on several occasions. The research topics which have been discussed in the project are within two highly actual fields: safety management and safety culture related to nuclear power. The findings are new. Several of the participants are young researchers.

One seminar has been arranged, from which the presentations have been documented in NKS-106. Two other NKS reports have been published. The main achievement to distribute knowledge has been writing of the book: “Nordic perspectives on safety management in high reliability organisations” (Akademitryck, Valdemarsvik 2005). This book can be used in education (competence development) and in that way it is useful for the end users.

1.4.4 Barriers, Control and Management

Title	**Barriers, Control and Management**
Identification number and Acronym	NKS-R 2002_07, BarriersControlManagement
Duration	2002-2004
NKS funding 2002-2005	0,695 MDKK
Leader	Morten Lind, DTU (DK)
Participants	DTU (DK), VTT (FI), SwedPower (S), Forsmarks Kraftgrupp (S)
Deliverables	M. Lind: Barriers, Control and Management. Report from the pilot phase. NKS-87, September 2003 Johannes Petersen: Countermeasures and Barriers NKS-113, October 2005 Morten Lind: Modeling Goals and Functions of Control and Safety Systems -theoretical foundations and extensions of MFM. NKS-114, October 2005
Evaluated deliverables	NKS-87, NKS-113, NKS-114

The objective of the activity: Barriers, Control and Management was to investigate how formalized concepts can be used to define concepts that can be used in design and assessment of nuclear power plant safety systems and procedures. The activity was conducted by Technical University of Denmark in 2002-2004. The total NKS-R funding to the activity was 0,695 MDKK. Three reports have been published in NKS series: *Barriers, Control and Management, Report from the pilot phase, NKS-87, Countermeasures and Barriers, NKS-113* and *Modeling Goals and Functions of Control and Safety Systems -theoretical foundations and extensions of MFM, NKS-114.*

The activity was started by a pilot phase, during which a large number of meetings and workshops were arranged to discuss the work between the other Nordic organizations (SKI, VTT, Forsmark, Linköping University, Risø). The pilot phase was reported in NKS-87, which is a compilation of separate summaries describing the research issues and hypotheses, the selected theoretical foundation, and an application example. The case study used as an application example: modeling of the Forsmark nuclear power plant modification and safety review processes was maybe too ambitious for the pilot phase. The report gives first a good, structured analysis of the plant modification process. The main theoretical novelty by the activity is application of Von Wright's action concepts to the plant modification and review processes. Here the pilot phase report is quite thin: the main part presents the formalism, whereas the application examples are simple. Conducting the case study in the beginning of the work has merit for the activity, because it has guided the investigation in the main phase of the work.

The report NKS-113 describes investigation of theoretical issues connected to Haddon's strategies for reducing and avoiding damages. The strategies (countermeasures) have been classified and analysed in a way that clearly illustrate their internal structure. The report continues with an analysis of the barrier concept, which is widely used in connecting with nuclear safety. Suggestions for more precise terminology have been given. Finally, the role of communicative actions in countermeasures has been discussed. The work reported in NKS-113 is useful in pointing out ambiguous terminology and explain ways to improve it. It is also quite theoretical, however.

The main phase of the activity has been reported in NKS-114. The report focuses on showing that a theoretical basis to model goals and functions in multilevel flow modeling can be constructed from the Von Wright action theories, already discussed in the pilot phase. The main part of the work is theoretical; the example is in this case quite simple: regulation of level in a tank.

The work done within the activity gives interesting theoretical insights to the concepts routinely used in the nuclear safety work. On the other hand, the methods are quite far from being applicable to practical cases. Significant additional work would have been required for the method to have added value in practise.

1.4.5 Experiments on Ruthenium behaviour in severe accident conditions

Title	**Ruthenium releases**
Identification number and Acronym	NKS_R 2002_12, RutheniumReleases
Duration	Started in 2002, continues in 2006
NKS funding 2002-2005	0.9 MDKK
Leader	Ari Auvinen, VTT (FI)
Participants	VTT (FI), STUK (FI)

Deliverables	U. Backman et al.: Ruthenium behaviour in severe nuclear accident conditions - progress report. NKS-92, March 2004 U. Backman et al.: Ruthenium Behaviour in Severe Nuclear Accident Conditions - Final Report. NKS-100, August 2004
Evaluated deliverables	NKS-92, NKS-100, NKS-118

Ruthenium releases is an experimental project that has been conducted by VTT. The activity has been part of NKS-R since 2002, and is still continuing in 2006. During 2002-2005, it has received 0.9 MDKK NKS funding.

The project deals with the behaviour of ruthenium in the primary system. Ruthenium can be released in situations where air comes in contact with the reactor core. The question is relevant for PWRs and BWRs during maintenance shut down. The work is thus of interest for all LWR reactors. The results of the work will later have impact on work on PSA level 2 and at the development of different calculation tools and will thus be used by authorities and industry. Furthermore the work has developed and maintained Nordic competence.

The project has published two reports in 2002-2005 and a third one in 2006. The reports are considered to have high international standard. Substantial parts of the work have been done by PhD students and the work has a Nordic dimension through the research subject.

A minus is that the work has not created or maintained Nordic network. Except VTT and the end user STUK, no other Nordic organisations have participated in the work. The activity results have been discussed in international, not in Nordic forums.

1.4.6 Traceability and communication of requirements in digital I&C systems development

Title	**TACO**
Identification number	NKS_R_2002_16
and Acronym	DigitalRequirements
Duration	2002-2005
NKS funding 2002-2005	0.95 MDKK
Leader	Terje Sivertsen, IFE (NO)
Participants	IFE (NO), VTT (FI), Ringhals AB (S)
Deliverables	T. Sivertsen et al.: Traceability and Communication of Requirements in Digital I&C Systems Development. Project Report 2003. NKS-91, March 2004. Terje Sivertsen et al: Traceability and Communication of Requirements in Digital I&C Systems Development - Project Report 2004. NKS-103, April 2005 Terje Sivertsen et al: Traceability and Communication of Requirements in Digital I&C Systems Development. Final Report. NKS-115, October 2005 Seminar: Traceability and Communication of Requirements in Digital I&C Systems Development, 2nd TACO Industrial Seminar, December 8, 2004, Helsinki, Finland
Evaluated deliverables	NKS-91, NKS-103, NKS-115

Traceability and Communication of Requirements in Digital I&C Systems Development (DigitalRequirements, TACO) has been conducted by IFE in 2002-2005. During that time the activity received 0.95 MDKK from NKS. The project work has been reported in three administrative reports.

The number of participating organisations was quite limited (IFE, VTT and Ringhals) and the number of young scientist was low.

Distribution of the TACO results has been made at “Industrial seminars”, one in Sweden (SKI) and a larger public seminar in Finland (STUK). The seminars have been considered well planned and carried out. It was pointed out, that this type of result distribution should also be done in other NKS projects.

Evaluation done in SKI considered that the project subject is important and interesting, and that the value of the work was good. The evaluator regarded the developed structure as new but pointed out that it should be tested in some practical case in order to evaluate its usefulness.

The SKI evaluation recommended that even if the seminars increased the distribution of the results, the end users should be involved in a more active way in the future. This should increase the possibilities to test developed methods and strategies on real cases and demonstrate the practical applicability. It was further commented that a theoretical model may look good and be structured but when it is applied on real cases, it fails and interface problems are discovered. Eventually this means that the theoretical model has to be modified in order to increase the applicability.

A STUK reviewer considered the scientific level of DigitalRequirements average, or slightly above, compared to other similar projects, methods or approaches in the international field.

The STUK review observed that the project had produced distinct and measurable goals in the requirements documentation scheme itself (“TACO Shell”) and the associated “TACO Traceability Model”. They can serve as platforms for a structured requirements representation and tracing in lifecycle oriented project work.

The reviewer pointed out that TACO has sought international contacts by being presented on relevant international forums, however, being limited to those with direct proximity to the Halden Project.

A common judgement of the reviewers was that requirements engineering is central to the utilisation of digital technology in safety critical or safety relevant applications (nuclear and other). Future NKS-R work in the area was warranted, but more emphasis should be placed on practical implementation / utilisation of results in actual power plant and/or regulatory work.

1.4.7 Nordic thermal hydraulic and nuclear safety network

Title	**Nordic thermal-hydraulic and nuclear safety network**
Identification number	NKS_R_2004_35
and Acronym	NOTNet
Duration	2004
NKS funding 2002-2005	0.3 MDKK
Leader	Jari Tuunanen, VTT (FI)
Participants	Westinghouse Atom (S), KTH(S), LUT (FI)
Deliverables	Jari Tuunanen and Minna Tuomainen: Final Report of the "Nordic Thermal-Hydraulic and Safety Network (NOTNET)"- Project. NKS-107, April 2005
Evaluated deliverables	NKS-107

NotNet was a specific activity to investigate prerequisites for establishing a Nordic network in the field of thermal hydraulics. The study was financed by 0.3 MDKK and conducted in 2004.

The report *Nordic Thermal-hydraulic and Safety network (NOTNET), NKS-107* gives a summary of the study. The report is not a traditional research report and the scientific content is low. It is more documentation of the background for a decision to start a new network. The available resources for research on thermal hydraulics in Sweden and Finland are reviewed. The research needs of the stakeholders are reviewed. A possible plan for work structure in the form of roadmaps with feedback from the stakeholders is described. Potential funding sources outside the NKS are reviewed. The original three roadmaps proposed are described.

The Nordic aspect of the NOTNet was significant. One objective of the network is to support the research organisations by the stakeholders in order with useful research tasks for younger researchers.

During the review the network was in the planning state. Progress has been made in 2006 with signing of contracts for the co-operation, now called Northnet, by several Nordic organisations.

1.4.8 Ex-vessel coolability and energetics of steam explosions in Nordic boiling water reactors

Title	**Ex-vessel coolability and energetics of steam explosions in Nordic BWRs**
Identification number and Acronym	NKS_R_2004_36 ExCoolSE
Duration	Preproject 2002; Started 2004, continues in 2006
NKS funding 2002-2005	0.98 MDKK
Leader	Hyun Sun Park, KTH (S)
Participants	KTH (S)
Deliverables	H. S. Park et al: Ex-Vessel Coolability and Energetics of Steam Explosions in Nordic Light Water Reactors - EXCOOLSE Project Report 2004 NKS-112 Oct 2005
Evaluated deliverables	NKS-112

ExCoolSE is an experimental project conducted by KTH since 2004. ExCoolSE was preceded in 2002 by a preparatory activity, PreDeliMelt (NKS_R_2002_14). ExCoolSe and PreDeliMelt received from NKS 0.98 MDKK in 2002-2005.

ExCoolSE deals mainly with two questions related to Nordic BWRs. One of them is the question of coolability of a molten core in the containment and the other is related to steam explosions. The same questions are considered within the cooperation project APRI (Accident Phenomena of Risk Importance) in which the SKI and the Swedish nuclear power industry are involved.

ExCoolSe has published one report in NKS series: *Ex-vessel Coolability and Energetics of Steam Explosions in Nordic Light Water Reactors, NKS-112.* The report has high international quality and the questions concerned are central for Nordic BWRs. It has contributed to the maintenance of Nordic competence within the field, and has involved young scientists. Most of the work has been carried out by PhD students.

The work has a Nordic dimension through the objective of the study (Nordic BWRs). The work has been conducted by KTH alone. Connections to other Nordic organisations have been few, especially to organisations outside Sweden. Information of the results has been given in international and Swedish (APRI) meetings.

1.5 Conclusions by the NKS-R evaluators

The evaluation of the NKS-R activities should be seen against the background that the financial resources are very limited. Total annual funding is about 2 500 kDKK (with 2 200 available at the time for activity proposals.). It should be considered that the cost for manpower in the Nordic countries is about 100 kDKK/manmonth. This means that the NKS-R funding covers about 25 man months per year. Thus, split on the five member countries equally there are as an average 5 man months available per year. Naturally, the NKS-R activities can only have a marginal impact on the research, competence development, network building etc. In case the funding is split on many projects as during 2002-2005, (23 projects), some of them will have very limited funding, corresponding to 1-2 man months.

Considering the limited funding, the achievements of NKS-R program in 2002-2005 have been remarkable. Only a few delays have been observed in conduction of the activities. In a vast majority of cases, the activity leaders have conducted their activities according to the plans, in a cost-effective way. The end users have considered the results applicable. All finished activities have fulfilled the formal NKS requirement of producing final documentation.

Most of the interviewed persons and survey answers seem to be satisfied with the current way of working within NKS-R. There were no wishes to return to the older system, applied prior to 2002.

The reporting activity must be especially mentioned. Results of the NKS-R activities have been published in 28 reports in NKS series alone. The scientific level of the reports is considered to be on an international level.

Nine seminars have been arranged, some of them receiving a very positive feedback. Another type of NKS-R seminar activity has been internal seminars for activity leaders. These are also considered very useful for effective conduction of the program.

There is a significant difference in the number and funding of activities managed by organisations in different Nordic countries. The activities managed by VTT have received by far the largest share of NKS-R funding in 2002-2005, almost 50% of the total. The current call for proposals procedure seems to favour large national research organisations (VTT, IFE) compared to the universities.

There are some NKS objectives that have not been completely fulfilled. The NKS-R framework report requires that proposals should demonstrate so-called “Nordic dimension”. The Nordic dimension has been interpreted as creation or maintenance of Nordic networks, transfer and build-up of Nordic competence, and involvement of young Nordic researchers and research teams. All activities have shown at least some aspects of Nordic dimension. Building of Nordic networks has been only occasionally achieved, however. There are some examples of real joint Nordic activities, sharing the work with several Nordic organisations from at least two countries. On the other hand, in most of the activities the main work has been conducted mainly by the leading organisation. An

indication of this can be seen in the reporting. Only two activities: DigitalRequirements and MainCulture have produced reporting having authors from more than one country.

Weak contacts of the NKS-R research to power plants and with the established Nordic co-operation groups were mentioned on several occasions in the survey and in the interviews. One reason for this may be that the activity proposals typically come from organisations, who do not have good information on the current interests at the power plants. Surprisingly, NKS-R contacts with the NKS-B part have been almost non-existent. No activities with joint objectives or joint participation have been initiated in 2002-2005.

Young scientists have been involved in the activities to some extent. The generation shift is a concern for the Nordic countries; therefore development of competence is an important factor for all. Organized education, as a series of seminars and/or regular education in relevant subjects could be considered. Possibly such facilities as the TRIGA reactor in Finland, a Full scale simulator in Sweden and facilities at Halden/Kjeller could be used.

The NKS-R seminar activity on specific topics must be considered good. It must be pointed out however, that there has been no general NKS-R seminar to give information of the total program results for a larger public. There should be a procedure to arrange such a seminar at certain intervals, e.g., 2 – 4 years.

The procedure and schedule to submit a proposal is not known to everybody. The information is easily available at the NKS www-site and has been there since 2002. Some comments still seem to refer to the old “top-down” system, in which the initiating agent was NKS, whereas the initiative now comes from the proposals having a relatively free form. Actually, several persons commented that it would be easier to submit a proposal, if NKS could better specify what it expects from the NKS research projects.

1.6 Recommendations (NKS-R)

The status of the program was found good, and most of the persons who expressed their opinion in the evaluation seem to be satisfied with the current system. Still, it is recommended to evaluate and to reconsider the program at regular, for example 4-5 year intervals.

An apparent observation is the modest Nordic co-operation within the current program. In many cases the activities have been conducted by organisations from one country only, sometimes by single organisations. Optional methods to enhance the co-operation could be:

- to initiate activities with the specific objective of creating Nordic networks and co-operation
- to enable the program manager to merge activity proposals having similar contents into a single joint activity at early stage
- to give extra credit in the activity proposal evaluation, if the proposal involves organisations from several Nordic countries
- to require that each activity must have participating organisations from at least two Nordic countries

NKS-R contacts with the established Nordic co-operation groups, with the end-users and with NKS-B should also be reinforced. More specific definition of the end-user needs should be required

of the proposals. The board members could take an active role to establish ties of the NKS-R activities to the Nordic co-operation groups and to the end-users in their country.

Common activities should be established between NKS-R and NKS-B. The accident phenomena and fission products studied within NKS-R are initial conditions to the emergency preparedness in NKS-B, giving possibilities for joint projects.

Distribution of the NKS-R results should be improved. One way to this objective is arrangement of seminars presenting the results of the program activities. Arrangement of seminars can also be an efficient way for establishing Nordic networks and cooperation. They will also contribute to the development of know how for a wider group of people.

Education activities, especially for the younger generation, could be a regular feature of NKS-R. The education could efficiently utilise the facilities available in various Nordic countries.

The call for proposals and the criteria used in proposal evaluation should specify the objectives that NKS wants to see from the research activities. A practical difficulty is that the NKS funding covers only a part, maximum 50% of an activity total funding. For the activity leader, it might not be possible to lead the research in a direction given by the NKS requirements. The NKS should be active to look at projects having established funding, and to see whether the objectives coincide.

Because of the limited research budget of NKS-R, extensive research projects, requiring expensive equipment, can not be carried out without strong support from other organizations. In such cases NKS funding has a minor impact on the project. It is a question of policy whether NKS-R should support large (highly scientific) projects or concentrate on minor (less scientific) projects.

For discussion, even more far-reaching changes can be imagined:

- To streamline distribution of funds, it is possible to think that NKS only gives a preset (and relatively modest) maximum funding for a certain activity.
- To emphasise the NKS role, it could be possible to focus NKS funding for only certain types of exercises, such as seminars, literature surveys, exploration of new conferences and fields, initiation of new network building, or relatively small research exercises.
- It could also be possible to reserve a part or all NKS funding only for the young generation and/or education.

1.7 References

NKS Programhandbok, NKS(06)3. www.nks.org

NKS Administrativ håndbok, NKS(06)4. www.nks.org

Reactor Safety Part of the NKS Program. NKS-R Framework, NKS(05)4. www.nks.org

2. Evaluation of the NKS Emergency Preparedness, NKS-B, 2002-2005

2.1 Overview of NKS-B programme

2.1.1 Framework

The aim of the NKS-B programme (Ref NKS-B Framework, version 2.1. 16.8.2004) is to *strengthen radiological emergency preparedness* in the Nordic countries. Apart from activities directly targeted at emergency preparedness this also includes activities in related areas such as *radioecology* and effective *communication and information management.* Also these activities must, however, be focused on emergency preparedness related questions.
Two main aspects are given highest priority:

1. Maintaining and building up *competence*, and
2. Maintaining and building *close informal Nordic networks* between scientists in emergency preparedness related disciplines.

The programme is structured on three basic fields:

- Research activities, investigations, exercises etc.
- Seminars
- Education

Research activities, investigations and exercises fall within the following three categories:

- *M: Measurement Strategy, Technology and Quality Assurance* (e.g. systems for mobile measurements, standardisation, intercomparisons)
- *R: Radio-ecological Studies* of relevance for emergency preparedness. (e.g. transfer of radionuclides in semi-natural terrestrial environments, including forests and semi-arctic environments, marine environments of special importance, syntheses of earlier radioecological studies of Nordic interest.)
- *E: Emergency Preparedness* in general and specific tools (e.g. exercises and similar activities; harmonisation activities; handbooks on countermeasures, actions etc, improved systems for information and communication, decision support systems.)

The general criteria for evaluating proposals are described in the document NKS(06)3 NKS(02)6 “Programhandbok”. Amongst the criteria for evaluating proposals are:

- how well the proposal falls within the defined NKS-B framework
- building-up of competence and maintaining it in the future
- value for co-operation of the Nordic authorities
- the ambition shall be that at least three countries are involved in each accepted activity, where so is feasible
- potential use of results and information
- how well it falls within the focus defined jointly at the time and also by the countries the potential participants represent
- the scientific and pedagogical merits of the proposal

But emphasis must also be put on the following fundamental criteria:

- It has to be ensured that the work performed within the NKS-B programme is relevant for the authorities and others financing the programme. This is a key issue in the evaluation process.

- All activities in the new programme need not be relevant for all of the supporting Nordic authorities, but it is very important that the NKS-B programme as a whole is highly relevant for them all.
- Interest of potential end-users must be clear.

The present evaluation is based on guidelines dated December 7th, 2005, set out by the NKS Board (see Appendix). For the evaluation, the above-mentioned guidelines were interpreted into ten different criteria, firstly some that judge how well the projects fulfil the aims of the programme, secondly criteria that judge the scientific and pedagogical merits of the projects as well as their usefulness and relevance for authorities and end-users. For each project evaluation against each of the ten criteria is graded by a score ranging from "very good" to "very poor" (A to E). To obtain an overall "quality figure" for each project, a weighted sum over all ten criteria is calculated, with the following weights given to each grade mark: A=16, B=8, C=4, D=2, E=1. A main grade has been given to each project based on the weighted sum over the ten evaluation criteria. The main grade has been set from the following values of the weighted sum of grades:

Main grade	Range of weighted sum
A	> 130
A–	110 - 129
B+	90 - 109
B	70 - 89
B–	50 - 69
C	< 50

A general evaluation summary is given for each project category, whereas recommendations and conclusions are set out in a final chapter.

2.1.2 NKS-B projects in the period 2002-2005

Table 8. Projects performed during the period 2002-2005, with total NKS-funded expenses during the period, amounting to 10,01 mill DKK for the entire period. Projects continuing into 2006 are marked by *.

Acronym	Project title	Reports	Cost (kDKK)
Measurement technology:			
MGS-ModMeth	Co-ordination and modernisation of methods for AGS and CGS measurements of multi-nuclide contamination	NKS-85	85
MGS-Course	Course in advanced methods for processing AGS and CGS data and similar sets of spectral data		65
ECCOMAGS	Nordic-EU collaboration on design and evaluation of the Resume 2002 exercise	NKS-86	200
ASS-1	Area specific stripping for CGS and AGS	NKS-125	60
ASSb	Area Specific Stripping of lower energy windows for AGS and CGS NaI systems. PART 2	NKS-109	180
SampStrat	Sampling strategy and sample preparation in emergency situations	NKS-122	95
Labinco	Intercomparison of laboratory analyses of radionuclides in environmental samples	NKS-144	350
RadChem	Radiochemical analysis in emergency and routine situations	NKS-124 NKS-129	415
NorCMass	Nordic collaboration on the use of mass-spectrometers for the analysis of radioisotopes	NKS-134 NKS-135 NKS-136	610

Radioecology:

Nova Course	Additional funding of Ph.D. course in radioecology		40
Rein	Regional differences in reindeer radiocaesium contamination		85
CsKinetic	Human metabolism of caesium	NKS-120	130
RadSem	Radioecology and measurement techniques		100
Forest*	Guidance for sampling in forests for radionuclide analysis and update of the Nordic forest radioecology network		225
ECODOSES*	Improving radiological assessment of doses to man from terrestrial ecosystems	NKS-98 NKS-110 NKS-123	1010
INDOFERN	New indicator organisms for environmental radioactivity	NKS-140 NKS-143	3030

Emergency preparedness:

Irades	Internal Radiation Doses in Emergency Situations	NKS-128	100
Knowledge-base	Nuclear threats in the vicinity of the Nordic countries - A base of knowledge	NKS-121	150
NordRisk*	Nuclear risk from atmospheric dispersion in Northern Europe.		160
CommTech	Communication technology and emergency preparedness		180
UrbContSem	Urban contamination seminar		260
NucVess	Impact assessment of accidents with nuclear powered vessels - analysis of release mechanisms and source term composition	NKS-138 NKS-139	340
UrbHand*	Decision Support Handbook for remediation of contaminated inhabited areas		410
MetNet*	Nordic network of meteorological services engaged in nuclear emergency preparedness		590
EMARAD	Emergency management & radiation monitoring in nuclear and radiological accidents	NKS-137 NKS-142	1140

2.1.3 Project cost distributions

As summarised in figure 13, the 9 measurement technology projects have received 21 % of the programme funding; the largest share (46%) went to the 7 radioecology projects, of which EcoDoses and Indofern are the two larger ones, representing each 10 % and 30 % of the NKS-B programme funding in the period. Emergency preparedness received 33 % of the funding, of which EMARAD took the largest share (11 %). The Programme Manager's funding is not included in the above figures and represents an addition of 15 % administration cost to the total project funding.

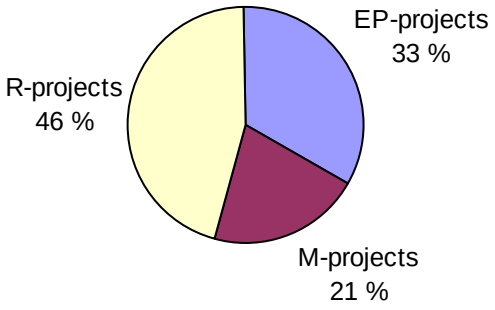


Figure 13. Distribution of NKS-B project costs on project type according to classification shown in Table 1 (ASSb is classified as Measurement Technology, CsKinetics as Radioecology, although both originally were classified as Emergency Preparedness projects.)

The distribution of project costs among various participating countries is shown in figure 14, for each of the three project types. The individual countries represent quite different participation profiles.

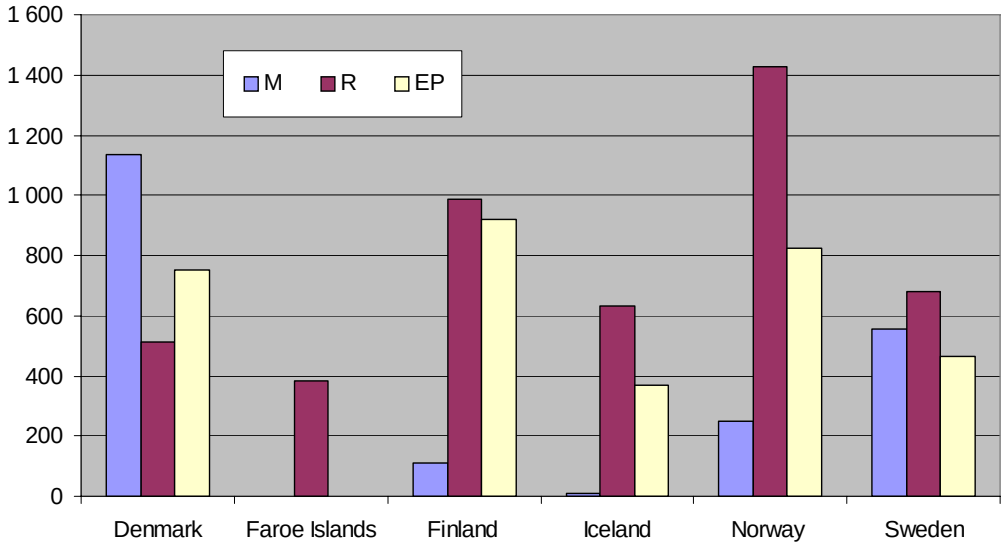


Figure 14. Distribution of NKS-B project costs (in kDKK) among participating countries for different project types: Measurement technology (M), Radioecology (R), Emergency preparedness (EP).

It should be remembered that the various countries may be engaged in bilateral programmes that are not part of the NKS programme. Thus, SSI of Sweden had for 12 years a direct collaboration with the Baltic States in much the same areas as covered by the NKS-B programme. This activity is now incorporated in the EU framework (SSI Report 2005:09).

The total project spending in each country is shown in figure 15, in percent of the total project cost of 10 010 kDKK. If these figures are combined with the distribution of spending within the NKS-R programme, a comparison can be made between funding and "return" for each of the Nordic countries (see figure 1).

As a general rule, each participating institution in a project shall contribute at least an amount of own funding equal to that received in NKS support. Thus, the NKS-B programme for the period 2002-2005 has had a project activity volume corresponding to 20 million DKK. In many cases additional financing from other sponsors have been significant, thus making it difficult to judge cost-effectiveness based on NKS funding alone.

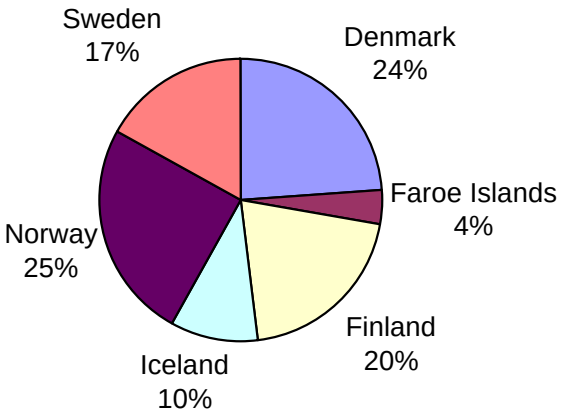


Figure 15. NKS-B Project spending in participating countries

2.1.4 NKS-B Seminars

(http://www.nks.org/nordisk/aktuelt/seminarier.htm)

- NKS-B Seminar on emergency preparedness, November 21, 2005, STUK, Finland
- NKS-B Summary Seminar, October 24 - 25, 2005, Tartu, Estonia
- NKS Seminar on decommissioning of nuclear installations September 13 - 15, 2005, Risø, Denmark

- NKS-B Seminar on Theory of Sampling (TOS) August 26, 2005, Risø, Denmark
- NKS-B CommTech Mini-Seminars, May 31 - June 1, 2005, SSI, Stockholm, Sweden
- NKS-B Mini-Seminar on Malicious Use of Radioactive Material, May 24 - 25, 2005, Stockholm, Sweden
- NKS-B RADSEM, August 19, 2004, Risø, Denmark
- NKS-B Mini-seminar on radioecology and measurement techniques, September 8-9, 2003, Risø, Denmark
- NKS-B sponsored Conference on Radioactive Contamination in Urban Areas (UrbContSem) May 7 - 9, 2003, Risø, Denmark
- NKS-B CommTech Mini-Seminar, February 27 –-28, 2003, STUK, Helsinki, Finland
- NKS-B Mini-seminar on Air-borne and Car-borne Gamma-Spectroscopy, October 17 - 18, 2002, DEMA, Denmark

2.2 Measurement technology

NKS projects on measurement technology may be subdivided into two types. The first type of projects address the task of rapidly and accurately mapping the deposition of radioactivity over large areas following a fall-out situation. The second type of projects are concerned with how to obtain precise and representative measurements of radioactivity in various material matrices sampled and subsequently subjected to sample analysis in the laboratory.

In the period 2002-2005 5 projects in the first category (MGS-ModMeth, MGS-Course, ASS-1, ASSb, ECCOMAGS) have been devoted to the further establishment of Nordic competence in air-born and car-born gamma spectroscopy (AGS and CGS, respectively), with significant contribution to in-the-field analysis of such data by area-specific spectrum stripping techniques. NKS contributed to Nordic-EU collaboration on design and evaluation of the Resume 2002 exercise (ECCOMAGS).

The 4 NKS projects in the second category concentrate on laboratory techniques for radiochemical analyses (RadChem), including a laboratory intercomparison study (Labinco). Nordic collaboration on the use of mass-spectrometers for the analysis of radioisotopes was initiated (NorCMass). The important aspect of sampling strategy and sample preparation in emergency situations (SampStrat) was raised at the end of the period 2002-2005.

2.2.1 MGS-ModMeth

Earlier projects within NKS had unveiled that Nordic teams performing Airborne or Car-borne Gamma-Ray Spectrometry (AGS and CGS) used different definitions and methods for data processing and presentation. Almost all investigations have concerned caesium-137 as the only artificial nuclide that could be measured in the environment with ordinary AGS and CGS equipment. Therefore it was decided to initiate within NKS an examination of how to map other fall-out nuclides with AGS and CGS. As a first step a seminar was arranged on 17-18 October 2002.

Objectives

The following objectives were set for this project:

- Organise a 2-day seminar, Preliminary discussion of competences 17-18 October 2002

– Publish report with contributions from the participants (NKS-85)

Summary of evaluation

Title:	**MGS-ModMeth - Co-ordination and modernisation of methods for AGS and CGS measurements of multi-nuclide contamination**
NKS funding:	85 000 DKK
Co-ordinator:	Uffe Korsbech, DTU (DK)
Participants:	DTU (DK), DEMA (DK), FOI (S), SGU(S), SSI(S), NGU (NO), NRPA (NO), STUK (FI)
Evaluation material	Contract for 2002, 3 semi-annual progress reports 2002-2003, NKS-85
Published deliverables	NKS-85: "Co-ordination and modernisation of methods for AGS and CGS measurements of multi-nuclide contamination Report from a seminar", February 2003, 30p.
Missing deliverables	None

The seminar was held at DEMA on 17-18 October 2002. Here the participants presented how they would handle the mapping of four pre-defined fall-out scenarios. The presentations and discussions at the seminar showed that carrying out the measurements for some of the scenarios would be difficult or even impossible with ordinary equipment and data processing techniques presently used by some of the teams. The seminar resulted in a list of problems deserving attention. Among those was the question on when to prefer high sensitivity NaI detectors and when to prefer high-resolution HPGe detectors. A common definition on "detection levels" was also needed. Here the generation of sets of spectra with different levels and combinations of fallout nuclides was proposed. Among the outcomes of the seminar were two proposals for future NKS projects; one concerned mapping of low levels of iodine, and the other was a method for generation of stripping factors from ordinary survey spectra.

The seminar obviously represented a good discussion on the present status of competence, and resulted in two constructive proposals for further work. One of these have been pursued by NKS and produced significant results (ASS1 and ASSb).

Fulfilment of NKS-criteria

In addition to the experience gained by participants at the seminar, the results of this project are available as

- MGS-ModMeth NKS-85 report (30 pages)

"Co-ordination and modernisation of methods for AGS and CGA measurements of multi-nuclide contamination".

NKS evaluation criteria	**Fulfilment of NKS-criteria, MGS-ModMeth**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Good pedagogical merits for participants at the seminar, in discussing how to handle the mapping of four pre-defined fall-out scenarios. Potential scientific merit in planned projects.	B
The application and scientific perspectives of the project	Constructive proposals for further work were generated.	B

At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	The seminar resulted in two constructive proposals for further work.	B
Project results of adequate quality	One of the resulting proposals have been pursued by NKS and produced significant results (ASS1 and ASSb).	B
Project in accordance with plans and budget	Yes.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 85,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 170,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	Results are relevant for authorities and experts.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.2.2 MGS-Course

A course was organised to give participants experience in using advanced methods for AGS and CGS data processing. Focus was on how to use the NUCSpec software system, including exercises searching for lost sources by methods based on pre-calculated area-specific stripping factors.

Objectives

The following objectives were set out in the contract for this project

- Production of course material
- Organise course at DTU, 4-8 November 2002.

Summary of evaluation

Title:	**MGS-Course - Course in advanced methods for processing AGS and CGS data and similar sets of spectral data**
NKS funding:	65 000 DKK
Co-ordinator:	Uffe Korsbech, DTU (DK)
Participants:	Total of 8 course participants from Norway (1), Denmark (2), Sweden (5)
Evaluation material	Contract for 2002, 3 semi-annual progress reports 2002-2003, report to NKS (3s)
Published deliverables	None
Missing deliverables	None

Fulfilment of NKS-criteria

NKS evaluation criteria	**Fulfilment of NKS-criteria, MGS-Course**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Very good pedagogical merit through the learning and experience gained by the eight participants at the course. Potential scientific merit in future applications.	A

The application and scientific perspectives of the project	Training in the use of modern methods was provided.	B
At least three Nordic countries involved	Course participants from three Nordic countries.	B
Potential use of results and information	Practical experience gained considered to be of high value.	A
Project results of adequate quality	Results of this project lie in the experience gained by the course participants.	B
Project in accordance with plans and budget	Yes.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 65,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 130,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	Results are relevant for authorities and participating experts.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B+**	

2.2.3 ECCOMAGS

In the RESUME 2002 exercise (Rapid Environmental Surveying Using Mobile Equipment) areas in SW Scotland were surveyed for anthropogenic and natural radioactivity with Airborne Gamma Spectrometry (AGS), Car-borne Gamma Spectrometry (CGS) and in-situ measurements. This was part of the ECCOMAGS project (http://www.cordis.lu/fp5-euratom/src/eccomags.htm) under the 5th EU Framework Programme for European Calibration and Co-ordination of Mobile and Airborne Gamma Spectroscopy. NKS contributed to Nordic-EU collaboration on design and evaluation of the Resume 2002 exercise through the NKS-EccoMags project.

Objectives

The following items were defined in the NKS contract for ECCOMAGS:

- Participation in the ECCOMAGS Design and Evaluation Group (DEG) with statistical data processing of exercise results
- Development and reporting of an expanded NKS-format to use for exercise data.
- Presentation of project status at NKS-seminar 17-18 October 2002 in Birkerød, Denmark
- Delivery of a final report

Summary of evaluation

Title:	**ECCOMAGS - Nordic-EU collaboration on design and evaluation of the Resume 2002 exercise**
NKS funding:	200 000 DKK
Co-ordinator:	Simon Karlsson, SSI (S)
Participants:	SSI (S), Risø (DK)
Evaluation material	Contract for 2003, semi-annual progress report 2002, Final report NKS-86.
Published deliverables	NKS-86: "ECCOMAGS: Initial results from the RESUME 2002 exercise" February 2003, 34p
Missing deliverables	None

The planning phase in the Design and Evaluation Group included conducting a pre-characterisation study of the survey area and finalising measurement protocols developed under the 4th European Framework Programme. An important objective of the RESUME 2002 exercise was to validate these protocols in order to develop them as European standards for AGS following a nuclear emergency.

The RESUME 2002 exercise was carried out at the time planned, but due to restrictions in the use of helicopters, less data was obtained than had been hoped for. The partnership with the EU puts certain restriction on what reference can be made to data from the exercise before the EU publishes its own reports. Results from the exercise presented in the final report include composite maps and data produced at the exercise, and initial results from the post-exercise data analysis. The report also presents a format for processed data exchange developed by NKS experts and further refined for the exercise.

The RESUME 2002 exercise was the first European scale benchmark exercise for AGS. Initial results demonstrate the ability of European AGS teams to produce comparable results in almost real time, and the ability to co-operate for nuclear emergency response to produce composite deposition and dose rate maps of large survey areas. The Cs-137 deposition examined in the exercise included a range of activity levels, and the database generated from the measurements can be used for further investigation of data processing and mapping techniques.

Fulfilment of NKS-criteria

In addition to the direct experience gained by participants in the project, the result of the ECCOMAGS project is presented as: NKS-86: "ECCOMAGS: Initial results from the RESUME 2002 exercise" February 2003,May 2005, 31p.

NKS evaluation criteria	Fulfilment of NKS-criteria, ECCOMAGS	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques are an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Very good pedagogical merits through experience gained during exercise. Emergency preparedness, rather than scientific merits was the aim of the project.	A
The application and scientific perspectives of the project	Significant Nordic expertise is demonstrated, but more reference to international competence on these problems could be given.	B
At least three Nordic countries involved	Three Nordic countries participated in the RESUME2002 exercise, but the NKS project only involved two Nordic countries.	B
Potential use of results and information	Results and practical experience are of high value.	A
Project results of adequate quality	Results and practical experience are of high value.	A
Project in accordance with plans and budget	Yes.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 200,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 400,000 DKK. Fieldwork entails extra cost. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	Highly relevant results for experts and authorities were obtained.	A

Evaluation grade	
A (very good), B (good), C (average), D (poor), E (very poor)	**A-**

2.2.4 ASS1

This project is based on very limited NKS funding but efficient utilisation of the experience of a previously established Nordic group collaboration. NKS funding only contributes to covering the co-ordinator's cost. The project reports the results from a NKS project aiming at examining the possibilities for extracting stripping factors for Airborne Gamma-ray Spectrometry (AGS) data and Carborne Gamma-ray Spectrometry (CGS) data directly from the recorded set of data, i.e. without having to calibrate the detector systems on beforehand.

Objectives

The following items were defined in the contract for ASS-1:
1) A report describing the theoretical models, the procedures developed and the practical experiences with a limited amount of AGS data.
2) A report outlining how to eventually proceed with an extended project including several sets of input data of varying quality.

Summary of evaluation

Title:	**Ass1 - Area specific stripping for CGS and AGS**
NKS funding:	60 000 DKK
Co-ordinator:	Uffe Korsbech, DTU (DK)
Participants:	DTU (DK), DEMA (DK), SGU(S), SSI(S), NGU (NO), NRPA (NO), STUK (FI)
Evaluation material	Contract for 2003, 3 semi-annual progress reports 2003-2004, international publication Rad. Prot. Dosimetry 2006 (14p), NKS-125.
Published deliverables	H.K. Aage et al. "Experiences with area-specific spectrum stripping of Na(Tl) gamma spectra", Rad. Prot. Dosimetry, Feb 2006 (14 p) NKS-125: "Area Specific Stripping factors for AGS. A method for extracting stripping factors from survey data", 131p, April 2006.
Missing deliverables	None

An internal report was written which describes the ASS method and its practical application in necessary detail. The work in this project and ASSb is summarised in an international publication, which shows the feasibility of the approach, but also discusses some of the limitations. The project should be co-ordinated or integrated into larger programmes.

Fulfilment of NKS-criteria

The result of the ASS1 project is presented in a scientific publication in an international refereed journal, as well as in a detailed report, NKS-125.
The funding provided by NKS for this project has been 60 000 DKK. Obviously the participating partners have covered a much larger cost.

NKS evaluation criteria	Fulfilment of NKS-criteria, ASS1	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques is an identified project area.	B

Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	The detailed procedure set out in NKS-125 represents very good pedagogical merit by disseminating competence in application of AGS and CGS. High scientific merit through scientific publication.	A
The application and scientific perspectives of the project	Significant Nordic expertise is demonstrated, but more reference to international competence on these problems could be given.	B
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	Results and practical experience are of high value.	A
Project results of adequate quality	Results and practical experience are of high value.	A
Project in accordance with plans and budget	Yes. NKS contributed only minor project funding	A
Cost-effectiveness of total budget	The NKS financial support of the project has been 60,000 DKK. Obviously the participating partners have covered a much larger cost. The cost-effectiveness is very high, seen from NKS point of view.	A
Relevance for authorities and others	Valuable results for science and authorities were obtained.	A
Evaluation grade	**A-**	
A (very good), B (good), C (average), D (poor), E (very poor)		

2.2.5 ASSb

This project examined the possibilities for extracting stripping factors for Air-borne Gamma-ray Spectrometry (AGS) data and Car-borne Gamma-ray Spectrometry (CGS) data directly from the recorded set of data, i.e. without having to calibrate the detector systems on beforehand.

Objectives

The following items were defined in the contract for ASSb:

- Conversion of existing data to formats that can be read by ASS software
- Processing and evaluation of data
- Final report to NKS specifications

Summary of evaluation

Title:	**ASSb - Area specific stripping for CGS and AGS, Part 2**
NKS funding:	180 000 DKK
Co-ordinator:	Uffe Korsbech, DTU (DK)
Participants:	DTU (DK), DEMA (DK), SGU(S), SSI(S), NRPA (NO)
Evaluation material	Contract for 2004, semi-annual progress report Oct 2004, NKS-109.
Published deliverables	NKS-109: “Area specific stripping of lower energy windows for AGS and CGS NaI systems”, May 2005, 100p
Missing deliverables	None

The published report NKS-109 describes the methods in necessary detail, and also contains valuable examples from application of the methods in field exercises. The report contains references to

international scientific publications showing that Nordic experts have significant experience in this field.

The presented stripping problem is as a classical analysis problem that presumably has been the object of academic effort for many years. Although reference is given to some international stakeholders in this problem (IAEA, ICRU), one would expect that e.g. other European radiation protection authorities also have addressed this problem. It would be of interest to know what expertise or methods could be obtained from such sources.

The report mentions a few remaining problems, e.g. the variation in stripping factors with altitude for AGS, and the rapid changes with surrounding terrain "structure" for CGS. Others are possible confounding influences from air-transported radon with subsequent "de-localised" gamma-emissions, and the problem of detecting hidden Ra-226 sources, which will be treated as part of the Th stripping spectrum. One would, however, from analytical intuition expect that the presence of spectral components not present in the normal environmental spectrum should be detectable, e.g. as a localised deviation in the quasi-stationary relationship between the U- Th- and K-stripping factors estimated for a certain area. The linear dependence between especially Th and U, but also K stripping factors in terrain with little variability in composition could possibly be included in the model and utilised for detecting deviations from the expected relationship if an artificial source is present.

Fulfilment of NKS-criteria

In addition to the direct experience gained by participants in the project, the result of the ASSb project is presented as:

- NKS-109: Area specific stripping of lower energy windows for AGS and CGS NaI systems May 2005, 100p

NKS evaluation criteria	Fulfilment of NKS-criteria, ASSb	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	The detailed procedure set out in NKS-109 represents very good pedagogical merit by disseminating competence in application of AGS and CGS.	A
The application and scientific perspectives of the project	Significant Nordic expertise is demonstrated, but more reference to international competence on these problems could be given.	B
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	Results and practical experience are of high value.	A
Project results of adequate quality	Results and practical experience are of high value.	A
Project in accordance with plans and budget	Yes. NKS contributed only minor project funding	A
Cost-effectiveness of total budget	The NKS financial support of the project has been 180,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 360,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	Valuable results for experts and authorities were obtained.	A

Evaluation grade	
A (very good), B (good), C (average), D (poor), E (very poor)	**A-**

2.2.6 SAMPSTRAT

The project SAMPSTRAT was started in 2005 and it has been proposed that the project should continue in the period 2006 - 2007. The aim of the project is to develop a Theory Of Sampling for the assessment of radioactivity in emergency situations and to give recommendations for the application in both emergency situations and in general environmental radioactivity studies.

Objectives

The objectives of the SAMPSTRAT-project were/are:

- to arrange a NKS-B mini-seminar on Theory Of Sampling with special emphasis on radioactivity and emergency situations
- to develop a book with recommendations on sampling strategies
- to develop courses on Theory Of Sampling for students in environmental radioactivity and for personnel in charge of sampling programmes in emergency situations

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**SAMPSTRAT - Sampling strategy and sample preparation in emergency situations**
NKS-funding:	95,000 DKK (2005), 200,000 DKK (2006 - 2007)
Co-ordinator:	Elis Holm (Lund University Hospital)
Participants:	Lund University (S), IFE (N), Risø (DK)
Evaluation materials:	Project proposal, proceedings from mini-seminar at Risø, 26 August 2005; NKS-122
Published deliverables:	Presentations at a NKS-B mini-seminar at Risø, 26 August 2005. NKS-122: "Theory of Sampling – A mini-seminar under the NKS-project SAMPSTRAT", April 2006, 90 pp.
Missing deliverables:	None

The project has at the time of evaluation not been completed and the final project results can therefore not be evaluated. The result of the project so far is the mini-seminar on the theory of sampling that describes all errors involved in sampling of heterogeneous materials. Sampling errors of up to as much as 100 - 1000 times the specific analytical errors have been experienced. In a nuclear or radiological emergency where radionuclides have been dispersed in the environment, a lot of environmental samples are needed to assess both the radiological consequences and the need for remedial actions. The project goal of developing a sampling theory and fundamental sampling principles for the assessment of radioactive contamination is thus very important. The plan of preparing a book with recommendations as well as courses is judged to be highly relevant. The material presented at the mini-seminar would be useful as basis for this continued work.

Fulfilment of NKS-criteria

The measurable results of the SAMPSTRAT-project during the project period 2005 are:

- Project contract and project proposal of 2004

- NKS-B mini-seminar at Risø, 26 August 2005
- Presentations at the seminar

The results of the SAMPSTRAT-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, SAMPSTRAT**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which developing optimum sampling and measurement strategies on environmental samples is an identified project areas.	B
Nordic competence and network building and maintenance	The project has the potential to build up competence on fundamental environmental sampling strategies that are essential for assessing emergency situations.	B
The scientific and pedagogical merits of the project	The project has very good pedagogical merits in the identification of the need of developing university courses on the theory of sampling. Also the scientific merits are judged to be good.	A
The application and scientific perspectives of the project	The project results are at the end oriented towards practical application in nuclear or radiological emergency situations. The scientific perspectives of the project are judged to be good regarding the development of a comprehensive and coherent theory of sampling.	B
At least three Nordic countries involved	Three Nordic countries have been involved in the project.	B
Potential use of results and information	The end-users of the project results are those engaged in environmental sampling, e.g. university departments, research institutes and nuclear facilities as well as the Nordic emergency management authorities. The project results have a high potential of being used in emergency situations.	A
Project results of adequate quality	The quality of the mini-seminar is judged to be good.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 95,000 DKK. Consequently, the results of should be judged against a total manpower effort of 180,000 DKK. The cost-effectiveness appears to be at the right level for arranging a mini-seminar.	B
Relevance for authorities and others	The result of the project would (at the end) be relevant for the Nordic authorities engaged in emergency preparedness and response.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B+**	

2.2.7 Labinco

An intercomparison between 38 laboratories on analyses of radionuclides in environmental samples was carried out. Sample types included typical environmental materials and human food items. A total of 38 laboratories were included in the study, among them 2 from Denmark, 7 from Norway, 6 from Sweden, 3 from Finland, 1 from Iceland and 12 from Baltic states.

Objectives

Participating laboratories carried out laboratory analyses and reported the results. The results of the intercomparison were presented and discussed at a seminar in Estonia, 24-25, October 2005. The intercomparison results will be reported in seminar proceedings, which will also bring the seminar presentations, conclusions and recommendations.

Summary of evaluation

Title:	**Labinco - Intercomparison of laboratory analyses of radionuclides in environmental samples**
NKS funding:	350 000 DKK
Co-ordinator:	Sven P. Nielsen, Risø (DK)
Participants:	Laboratories in all 5 Nordic countries (19), Baltic states (12) and other countries (7)
Evaluation material	Contracts for 2004 and 2005, 4 semi-annual progress reports for 2004, 2005, Draft of data report, Feb 2006.
Published deliverables	NKS-144 Intercomparison of Laboratory Analyses of Radionuclides in Environmental Samples, October 2006, 59p.
Missing deliverables	None

Conclusions from this project were still being compiled at the time of evaluation, but although some laboratories still seem to have some difficulties and some types of measurements are clearly more difficult than others, it seems nevertheless that the laboratories are performing better than they have typically done in previous intercomparisions. 14 different nuclides plus total alpha and total beta were measured in 11 different matrices, although not all combinations were used, and not all laboratories submitted results for all types of measurement. Results varied considerably, e.g. 27 out of 35 laboratories (77%) passed the evaluation criteria for ^{137}Cs measurement, but only 3 out of 20 for ^{90}Sr (15%). This project could benefit from being integrated with the RadChem project (see below), i.e. at the same time identifying which procedures were used for the different analyses. It would be of interest to look for possible correlation between deviating results and the use of particular radiochemical preparation or measurement procedures. The project should be repeated at reasonable time intervals, and co-ordinated with RadChem type investigations.

Fulfilment of NKS-criteria

Funding for this project has covered the co-ordinator's cost to administer the intercomparison, planning of the seminar, as well as travel costs for Nordic participants (20 out of total number of 38 participants) to the seminar.

NKS evaluation criteria	**Fulfilment of NKS-criteria, Labinco**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques are identified project areas.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	A
The scientific and pedagogical merits of the project	Very high pedagogical merit through focus on methodological skills. The results of this intercomparison represent scientific knowledge of very high merit.	A
The application and scientific perspectives of the project	Important project to increase quality of radionuclide measurements in ecological samples.	A
At least three Nordic countries involved	All Nordic countries have been involved in the project.	A
Potential use of results and information	Results and practical experience are of high value.	B
Project results of adequate quality	Results and practical experience are of high value.	A
Project in accordance with plans and budget	Yes.	A
Cost-effectiveness of total budget	The NKS financial support of the project has been 350,000 DKK. Consequently, the results of the project should be judged against a	A

	total manpower effort of 700,000 DKK. Laboratory work entails extra costs. The cost-effectiveness appears to be at the right level.	
Relevance for authorities and others	Valuable results for participating laboratories and for authorities relying on these laboratories.	A
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**A**	

2.2.8 RadChem

Accurate determination of radionuclides from various sources in the environment is essential for assessment of the potential hazards and suitable countermeasures both in case of accidents, authorised release and routine surveillance. Reliable radiochemical separation and detection techniques are needed for the accurate determination of alpha and beta emitters. Rapid analytical methods are needed in the case of an accident for early decision making.

Objectives

The objective of this project was to perform critical evaluation of radiochemical procedures in terms of their reliability, reproducibility, rapidity, toxicity, cost, simplicity etc. Based on this, areas that need more research were singled out and possible new procedures developed. Radionuclides that deserve special consideration include U, Pu, Am, Cm and Sr. To gather detailed information on the procedures in use, a questionnaire regarding various aspects of radionuclide determination was developed and distributed to all (sixteen) relevant laboratories in the Nordic countries. In the second year of the project an intercomparison on the analysis of natural radionuclides in ground water was performed. A more complete intercomparison analysis programme should be integrated in the project.

Summary of evaluation

Title:	**RadChem - Radiochemical analysis in emergency and routine situations**
NKS funding:	415 000 DKK
Co-ordinator:	Rajdeep Singh Sidhu, IFE (NO)
Participants:	IFE (NO), LU (S), LiU (S), ØU (S), FOI (S), Risø (DK), HU (FI), STUK (FI)
Evaluation material	Contracts for 2004 and 2005, 4 semi-annual progress reports for 2004, 2005, Draft of final report, March 2005 (30s + appendices), NKS-124, NKS-129.
Published deliverables	NKS-124: "RADCHEM Radiochemical procedures for the determination of Sr, U, Pu, Am and Cm", April 2006, 94p. NKS-129: "RADCHEM 2005 - Radiochemical analysis in emergency and routine situations", April 2006, 22p.
Missing deliverables	None

Valuable information was provided by the labs on their practise regarding the specified analyses, making it possible to analyse and compare radiochemical preparation procedures. It is now 20 years ago since such a study was last undertaken in the Nordic countries. Although most of the techniques in use are still the same, some deviations can be seen: Besides Pu separation using anion exchange chromatography, there was not a single procedure that was used in all labs. More labs are doing americium determination. Due to the commercial availability of extraction chromatographic resins, more labs are now using this technique.

The report refers to several standard publications on radiochemical analysis. Questionnaire response from each participating laboratory is included. Nine laboratories answered the questionnaire, while four laboratories responded that they did not perform the specified analysis. Two laboratories that perform the specified analyses did not respond to the questionnaire. The report summaries the findings and gives recommendation on suitable practice.

Results of the planned intercomparison analysis of natural radionuclides in ground water were published in the proceedings from the NKS-B Summary Seminar in Tartu, October 2005. It would seem natural that the RadChem project was integrated into an analysis programme performed at the same time. It is mentioned that a comparison of the results provided by different labs in the NKS-B LABINCO exercise will provide a direct comparison of the different procedures in use.

Fulfilment of NKS-criteria

NKS evaluation criteria	Fulfilment of NKS-criteria, RadChem	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology and associated measurement techniques are identified project areas.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Very high pedagogical merit through focus on methodological skills.	A
The application and scientific perspectives of the project	Important project to assure quality and increase standardisation of radionuclide analysis in ecological samples.	B
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	Results may lead to more standardised laboratory practices.	B
Project results of adequate quality	Reported analysis protocols are of limited value as long as not supported by published intercomparison measurements.	C
Project in accordance with plans and budget	Yes.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 415,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 830,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	Potentially valuable results for participating laboratories and for authorities relying on these laboratories.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.2.9 NorCMass

The project NorCMass has been performed in the period 2003 - 2005. The aim of the project was to stimulate and expand the Nordic competence in radioisotope measurement technology and radiochemistry as the actual number of people in the Nordic countries being able to perform mass-spectrometric analyses is critically small. To achieve these goals guideline materials have been produced and workshops on mass-spectrometric measurements have been performed.

Objectives

The objectives of the NorCMass-project were:

- to stimulate contact between mass-spectrometry users in the Nordic countries
- to stimulate new students to enter the field of mass-spectrometry
- to prepare reference material for mass-spectrometric analyses for Pu/^{237}Np
- to produce thorough instruction on the use of different mass-spectrometry systems
- to plan a training course in radiochemistry and mass-spectrometry for the project participants as well as for the participants of the RadChem-project

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**NorCMass - Nordic collaboration on the use of mass-spectrometers for the analysis of radioisotopes**
NKS-funding:	150,000 DKK (2003), 260,000 DKK (2004), 200,000 DKK (2005)
Co-ordinator:	Per Roos (Risø/Lund)
Participants:	Risø (DK), FOI (S), Agricultural University of Norway (N), University of Linköping (S), University of Örebro (S)
Evaluation materials:	Project proposals, project reports, guideline materials, NKS-134, NKS-135, NKS-136.
Published deliverables:	Workshops on mass-spectrometric radioisotope measurements (Örebro, Risø and Helsinki) NKS-134: "Nordic Collaboration on the use of Mass-Spectrometers for the Analysis of Radioisotopes", April 2006, 15 pp. NKS-135: "NKS-Norcmass reference material for analysis of Pu-isotopes and ^{237}Np by mass spectrometry", April 2006, 12 pp. NKS-136: "The NKS-NORCMASS guide to beginners in ICP-MS", April 2006, 23 pp.
Missing deliverables:	None

The main purpose of the NorCMass-project has not been the scientific findings during the project period but merely to bring together scientists interested in the field of mass-spectrometry. Without the project this would not have been possible. The most important result of the project is that the skills on mass-spectrometric analyses among the participants have improved because of the participation in the project. Improved measuring techniques for reliable and rapid assessment of trans-uranium elements in environmental samples are important also from the aspect of emergency preparedness. In that perspective the project has contributed to improve the Nordic capabilities of a rapid assessment of, *e.g*. plutonium, in environmental samples collected in an emergency situation.

Fulfilment of NKS-criteria

The measurable results of the NorCMass-project during the project period 2003 - 2005 are:

- Project contract and project proposals of 2003 and 2004
- Workshop on radioisotope measurements with ICP-MS, Örebro, Sweden, 23 June 2004
- Workshop on ultra-low measurements, isotope ratios and necessary radiochemistry, Risø, Denmark, 18 August 2004
- Second workshop on ultra-low measurements, isotope ratios and necessary radiochemistry, Helsinki, Finland, 17 - 18 February 2005
- Working documents and reports:
  - Nordic Collaboration on the use of Mass-Spectrometers for the Analysis of Radioisotopes, NKS-134, April 2006

  - NKS-B Norcmass reference material for analysis of Pu-isotopes and ^{237}Np by mass spectrometry, NKS-135, April 2006
  - The NKS-NORCMASS guide to beginners in ICP-MS, NKS-136, April 2006
  - Schedule for "Training course in isotope ratio measurements of Pu and U at low levels using ICP-MS"
- Published papers in scientific journals and conference presentations:
  - Lanthanide phosphate interferences in actinide determination using inductively coupled plasma mass spectrometry. Journal of Analytical Atomic Spectrometry, 20, 1 - 6 (2005).
  - Isotope amount ratio measurements by ICP-MS: Aspects of software induced measurement bias and non-linearity. Journal of Analytical Atomic Spectrometry, 20, 320 - 322 (2005).
  - Rapid Method for ICP-MS Analysis of Plutonium in Sediment Samples. In: Scientific Basis for Nuclear Waste Management XXVIII. Materials Research Society, Warrendale, Vol. 824.
  - Pu-isotope measurements at femtogram levels using sector field ICP-MS. Accepted for publication in a special issue of Journal of Environmental Radioactivity.
  - Pu-isotope measurements at femtogram levels using sector field ICP-MS. International Conference on Isotopes in the Environmental Studies - Aquatic Forum, Monaco 25 - 29 October 2004.
  - Sources of plutonium in the environment and rapid methods for determination as emergency measures. 227th ACS National Meeting, Anaheim (2004).

The results of the NorCMass-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, NorCMass**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which developing optimum sampling and measurement strategies on environmental samples is an identified project areas.	B
Nordic competence and network building and maintenance	The project has built-up a Nordic network on mass-spectrometric measurements and has improved Nordic competence on the determination of trans-uranium elements in environmental samples using mass-spectrometric measuring techniques. The aspects of building networks and building up competences have been given the highest priority in the NKS-B programme.	A
The scientific and pedagogical merits of the project	The project appears to have good pedagogical merits, i.e. the guide to beginners in mass-spectrometry and the plan for training courses in low-level measurements of plutonium and uranium. The project is focused on practical application more than on long-term scientific merits.	B
The application and scientific perspectives of the project	The project results are oriented towards practical application in for the analyses of environmental samples, both for routine surveillance and in nuclear or radiological emergency situations. The scientific perspectives of the project are judged to be limited.	B
At least three Nordic countries involved	Three Nordic countries have been involved in the project.	B
Potential use of results and information	The end-users of the project results are those engaged in mass-spectrometric analyses of environmental samples, e.g. university departments, research institutes as well as the Nordic emergency management authorities. The improved skills on mass-spectrometric measurements from the project	B

	can be used in emergency situations where trans-uranium elements have been dispersed in, e.g. urban environments.	
Project results of adequate quality	The quality of the project is judged to be fairly good. The guideline material for ICP-MS beginners and the reference material for Pu-/Np-analyses are important deliverables; they might have been prepared in a more user-friendly form.	C
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 610,000 DKK. Consequently, the results of should be judged against a total manpower effort of 1,200,000 DKK. The cost-effectiveness appears to be somewhat low compared to the outcome of the project, i.e. high costs compared to the outcome of the project.	C
Relevance for authorities and others	The result of the project would be relevant for the Nordic authorities engaged in emergency preparedness and response and for those engaged in analyses of trans-uranium analyses.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.2.10 General evaluation of measurement technology projects

Projects on measurement technology are a very valuable part of the NKS programme portfolio. Nordic countries possess expert competence in this field, which is also appreciated on the European level. Nevertheless, radiological measurements constitute an expertise only mastered by few institutions in each of the Nordic countries. Projects within NKS therefore constitute an opportunity to further develop and maintain this competence as well as work out common protocols and procedures that will ensure co-ordinated actions within the Nordic countries in case of an emergency. Both types of projects (in-the-field measurements and laboratory-based analyses, respectively) seen within the 2002-2005 NKS programme are highly relevant and valuable. These are projects addressing the task of rapidly and accurately mapping the deposition of radioactivity following a fall-out situation, as well as projects measuring radioactivity in various material matrices sampled and subsequently subjected to sample analysis in the laboratory.

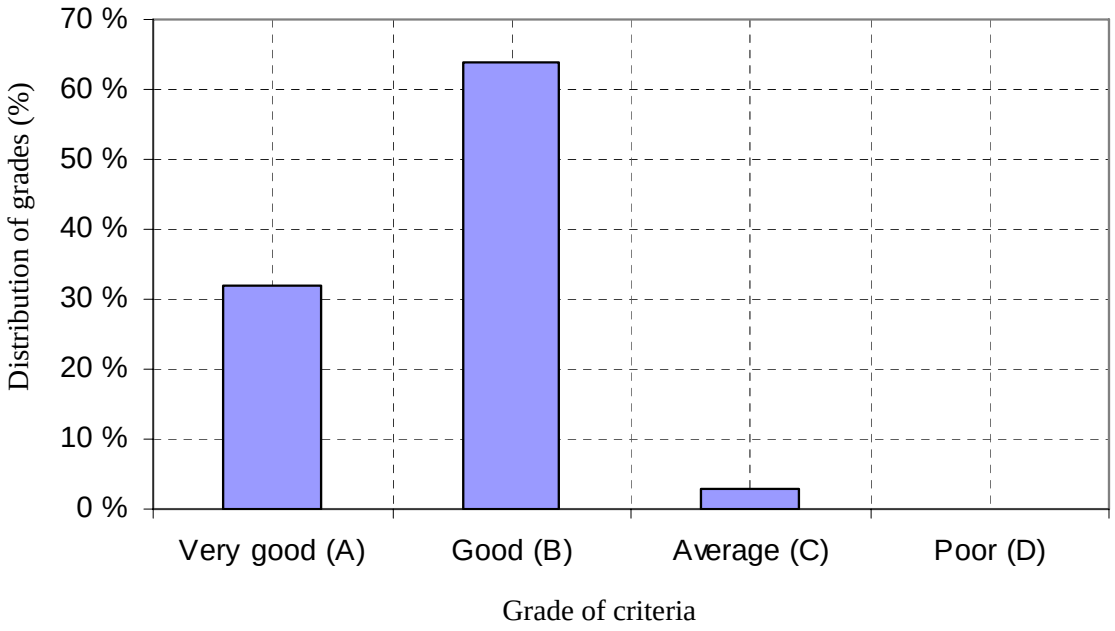


Figure 16. Distribution of grades for ten evaluation criteria over the nine measurement technology projects

Very valuable results have been obtained from field exercises and laboratory intercomparisons, respectively, for the two types of projects. Each project has been evaluated against ten criteria each of which has been given a grade (score) ranging from "very good" to "very poor" (A - E). No differential weighting has been given to these criteria and the final grade of each project is therefore a 'best judgement'. A crude averaging of the overall quality has been performed by adding (over all the projects and evaluation criteria) scores of the same grade (from very good to very poor) as shown in figure 16. The results indicate that the "average overall quality" of the nine measurement technology projects in general is quite good as more than 95% of all scores fall within the categories "very good" and "good". Despite the fairly good average score, individual differences in 'quality' exist.

To have an indication for the alleged differences in 'quality' between individual measurement technology projects the sum of grades of the same category (*A*, *B*, *C* etc.) over the ten evaluation criteria has been weighted using the following weighting algorithm:

$$\overline{G} = 2^4 \cdot N_A + 2^3 \cdot N_B + 2^2 \cdot N_C + 2^1 N_D + 2^0 \cdot N_E$$

where, *e.g.* N_A is the total number of *A*s scored for the project considered, each A representing a score of 16. The weighted sum of evaluation grades, $\overline{G}$, for each of the measurement technology projects is shown in the lower panel of figure 17.

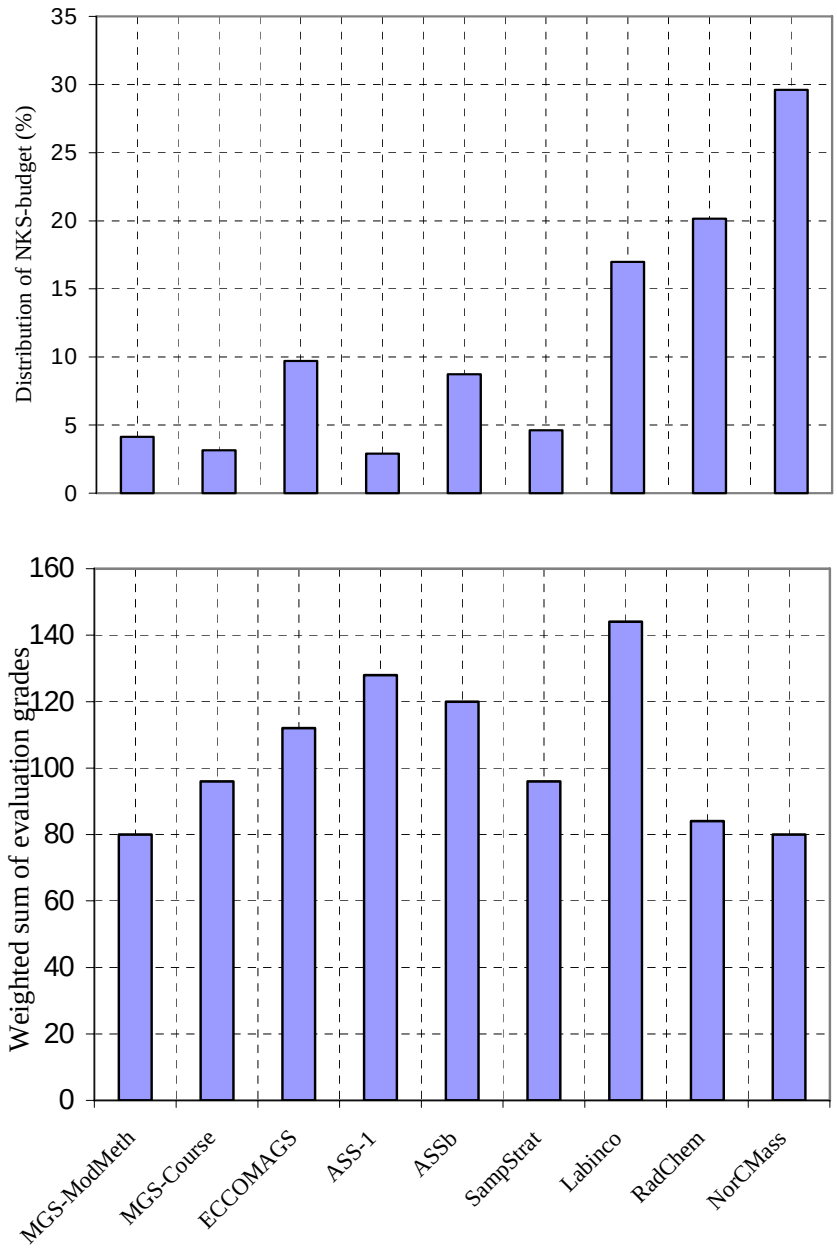


Figure 17. Relative distribution of the NKS-budget and weighted sum of grades for each of the nine measurement technology projects.

The total NKS-budget for measurement technology projects is 2 060 kDKK. The largest project is NorCMass, requiring 30% of the total funding for measurement technology projects. The relative distribution of NKS-budget on the nine projects is shown in the upper panel of figure 17. It may be noted that the two most expensive projects are not among those with the higher grades.

Challenges for the future will be to:

- Integrate project results into future activities.
- Include to a larger extent university personnel and graduate students in projects of academic interest and relevance.
- Integrate NKS activities better with relevant EU activities.

2.3 Radioecology

The NKS-B programme includes radioecological studies of relevance for emergency preparedness. Such projects may study e.g. transfer of radionuclides in semi-natural terrestrial environments, including forests, semi-arctic environments, and marine environments of special importance, as well as perform syntheses of earlier radioecological studies of Nordic interest.
The focus of NKS projects in radioecology is the possible radiation dose to man through relevant radioecological pathways. For this purpose, identification and monitoring of biological accumulation indicators in various environments becomes important. Recently the limitation of radioecology to human health protection has been questioned, and protection of the environment per se against possible effects of ionising radiation is being recognised (ICRP report 91, 2004). For this purpose biological response indicators in various environments become objects of study, as realised in the two EU programmes FASSET (Framework for Assessment of Environmental Impact) and its follow-up project in the 6th Framework Programme, ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management). In order to be complete and conclusive, such studies must, however, consider the whole range of environmental stress factors, and such studies are therefore considered outside the scope of NKS-B activities.

The NKS-B activities in radioecology have supported courses (NovaCourse) and seminars (RadSem), as well as more focused activities studying radioecological aspects in ecosystems of particular Nordic interest (Rein, CsKinetic, Forest). Most of the financial support has been concentrated on two large projects, one to evaluate doses to man from various elements of the ecosystem (EcoDoses), and one to search for new useful organisms accumulating effectively and specifically radionuclides of relevance in Nordic ecosystems (Indofern).

2.3.1 Nova Course

Title:	**NOVA Course - additional funding for PhD Course in radioecology**
NKS funding:	40 000 DKK
Co-ordinator:	Brit Salbu, NLH (NO) / Klas Rosén, SLU (SE)
Participants:	one student from each of four Nordic countries
Evaluation material	Contracts for 2003, 3 semi-annual progress reports for 2003-2004.
Published deliverables	None
Missing deliverables	None

Support was given from NKS for 4 students, one from each of the countries Norway, Finland, Sweden and Iceland. First part of the course was held January 6th-17th, 2003, second part June 2nd-6th, 2003. NKS took no part in organising the course, and this project is therefore not included in the evaluation of NKS projects.

2.3.2 Rein

Reindeer is the part of Nordic food production being most vulnerable to radioactive contamination. Despite numerous radioecological studies of reindeer and reindeer meat consumers in the Nordic countries over the last 40 years, there are still important areas of lacking knowledge.

Objectives

• Continue the work initiated under the NKS-B ECODOSES project which showed 2-3 fold differences in 137Cs ecological half-lives in reindeer between different regions. This will be done by synthesising available information on habitat use, reindeer diet and contamination of reindeer in Finland, Sweden and Norway, thereby obtaining a more thorough understanding of the situation.
• Assess regional differences in transfer of radiocaesium to reindeer, by analysing available information that can help quantify the importance of lichen and other vegetation in the reindeer's diet in different areas. In modern reindeer husbandry, especially in Sweden and Norway, slaughtering also occurs in early autumn. An up-to-date emergency preparedness requires information pertinent to this situation.
• Contribute to developing a dynamic model for radiocaesium in reindeer that can help identify knowledge gaps, and be a useful tool in Nordic emergency preparedness.

Summary of evaluation

Title:	**Rein - Regional differences in reindeer radio-caesium contamination**
NKS funding:	85 000 DKK
Co-ordinator:	Lavrans Skuterud, NRPA (NO)
Participants:	NRPA (NO), NINA (NO), SLU (S), FOI (S), STUK (FI)
Evaluation material	Contract for 2004, 3 semi-annual progress reports, status report March 2006
Published deliverables	Doctoral thesis NTNU 2005:151: "Investigation of selected natural and anthropogenic radionuclides in reindeer and lynx" is in part based on results from this project. The doctoral thesis contains 6 papers in international refereed journals (Rad and Environm Biophysics, and J Environm Radioact)
Missing deliverables	Unclear whether a final NKS-report will be published

Work within the project has led to a deeper understanding of factors influencing the radioecology of reindeer. The activity has been delayed, partly because the co-ordinator had to concentrate on his PhD thesis, "Investigation of selected natural and anthropogenic radionuclides in reindeer (Rangifer tarandus tarandus) and lynx (Lynx lynx)", which was successfully defended on August 29th, 2005. Part of the result has been to point out areas that need further investigation, such as:

- The proportion of lichen in the reindeer's diet, during all seasons, together with fallout pattern, are the important factors determining the contamination of reindeer during the first years after a fallout situation. In many areas the proportion of lichen in the diet is not well known. Additionally, grazing intensity needs to be included as a factor in studies of effective ecological halftimes.
- Observed difference in effective ecological half-times are more than a factor of 2 between Chernobyl affected areas in Sweden and Norway and areas less affected by the Chernobyl fallout further north. Further studies are needed to elucidate if the difference could be satisfactorily explained by differences in fallout origin alone or if other factors are also involved.
- Additional information regarding the long-term changes of radiocaesium in lichens and other vegetation important to reindeer would significantly help in understanding the dynamics of the radiocaesium transfer to reindeer.

Modelling is recognised as a helpful tool in this work, and would probably help extract more information from the already available data sets in Nordic countries. The model would also fill an

important gap in the other software applied in the emergency preparedness. The model will be applied to study the effects of e.g. various diets, ingested fungi, lengths of winter periods and animal age on ^{137}Cs concentrations in reindeer. The development of a model for radiocaesium in reindeer has started, based on the initial developments by Åhman and Nylén.

This project should be co-ordinated or integrated into larger programmes such as ERICA.

Fulfilment of NKS criteria

NKS evaluation criteria	Fulfilment of NKS-criteria, Rein	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	High scientific merit through systematic studies of important species for Norwegian radioecology. High pedagogical merit through supporting education of a PhD candidate.	A
The application and scientific perspectives of the project	Important questions in reindeer radioecology have been addressed. Reindeer is an important species in Nordic radioecology, as an important representative of Nordic fauna, but also because of its contribution to dose in humans through reindeer meat consumption.	A
At least three Nordic countries involved	Three Nordic countries have been involved in the project.	B
Potential use of results and information	Important areas for further studies have been identified	B
Project results of adequate quality	Difficult to assess, since final report has not been submitted.	C
Project in accordance with plans and budget	Project has been delayed.	C
Cost-effectiveness of total budget	Difficult to assess, since final report has not been submitted.	C
Relevance for authorities and others	Valuable results for science and authorities were obtained.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.3.3 CsKinetic

A study of the human biokinetics of caesium in two forms, i.) incorporated in foodstuff (137Cs in perch and mushrooms) and ii.) in ionic state (134Cs in aqueous solution) has been carried out at the Department of Radiation Physics in Malmö, starting in 2001. The results of the pilot study were published in 2004, and the CsKinetics project represents a continuation of the aforementioned study.

Objectives

i.) investigate whether Scandinavian populations exhibit shorter biological half-time of radiocaesium than other populations;
ii.) extend the biokinetic study to additional human subjects from the other Nordic countries.

Summary of evaluation

Title:	**CsKinetic - Human metabolism of caesium**
NKS funding:	130 000 DKK
Co-ordinator:	Christopher L. Rääf, Dept. of radiation physics, LU (S)
Participants:	LU (S), SSI (S), Risø (DK), NRPA (NO), STUK (FI)
Evaluation material	Contract for 2004, 3 semi-annual progress reports, draft of final report Sept 2005 (8 p), NKS-120.
Published deliverables	NKS-120: "Human metabolism of caesium", April 2006, 8p.
Missing deliverables	None

Results from the project indicate a near complete absorption of radiocaesium in the gastro-intestinal tract, be it in ion state or contained in food matrix. So far, the literature survey of Nordic studies on biokinetics of Cs suggests that the biological half time is somewhat shorter among Scandinavian males (84 days vs. ICRP-value of 110 days), although females do not exhibit any significant difference (64 days vs ICRP value of 65 days). The participants of the project have compiled a literature study containing more than 50 references on biokinetic studies of radiocaesium, with special focus on studies including some form of excretion sampling. The additional data provided by the project is based on controlled ingestion studies of ^{137}Cs-contaminated food and ^{134}CsCl in three adult volunteers, with subsequent excretion analysis. The project hopes to recruit more Nordic volunteers within a one-year period.

This project is important and relevant for Nordic radioecology. However, it is questionable whether the present project, even on the basis of prior work in Sweden, has the necessary statistical power to significantly demonstrate that biological half-time of radiocaesium in Nordic subjects may be different from standard values published by ICRP. This project should be co-ordinated or integrated into larger investigations.

Fulfilment of NKS-criteria

NKS evaluation criteria	**Fulfilment of NKS-criteria, CsKinetic**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition and analysis.	B
The scientific and pedagogical merits of the project	Heroic, but too limited project. Limited pedagogical merit.	C
The application and scientific perspectives of the project	Insufficient focus on statistical power of planned investigations.	C
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	Results are interesting and relevant, but not of sufficient statistical power to be significant.	C
Project results of adequate quality	Unclear whether project data were acquired under well-documented conditions and with adequate standardisation and quality assurance to be comparable to ICRP data.	C
Project in accordance with plans and budget	Plans and budgets reviewed and revised annually, with a tendency to prolong ongoing projects.	C
Cost-effectiveness of total budget	The NKS financial support has been 130,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 260,000 DKK. The cost-effectiveness is difficult to assess, but it could be improved by integrating results into larger analyses.	B

Relevance for authorities and others	Indications of valuable results for science and authorities were obtained.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B-**	

2.3.4 RadSem

Objectives

The objective was to organise a mini-seminar in September 2003, in co-operation with NSFS, on radioecology and measurement techniques. Compilation of proceedings from the seminar was to be published, at least as an electronic document.

Summary of evaluation

Title:	**RadSem - Seminar: Radioecology and measurement techniques**
NKS funding:	100 000 DKK
Co-ordinator:	PrgMan
Participants:	22 participants at first seminar, 18 at the second seminar.
Evaluation material	Contract for 2003, 2 semi-annual progress reports 2003, seminar web page
Published deliverables	Seminar web page, http://130.226.56.167/nordisk/publikationer/1994_2004/radsem/gamalt/index.html http://130.226.56.167/nordisk/publikationer/1994_2004/radsem/index.html
Missing deliverables	None

Mini-seminars were held on September 8-9, 2003 and August 19, 2004, at Risø, Denmark. Three NKS-B projects were presented at the first seminar, and possible future activities within NKS-B were discussed as well as work in neighbouring countries with possible links to NKS work. In the second seminar, eight NKS-B projects were presented seven of these subsequently published extended abstracts on the seminar web page.

Fulfilment of NKS-criteria

NKS evaluation criteria	**Fulfilment of NKS-criteria, RadSem**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition and analysis.	B
The scientific and pedagogical merits of the project	High pedagogical merit through seminar experience. The scientific merit of the project appears to be limited.	B
The application and scientific perspectives of the project	Application-oriented seminar	B
At least three Nordic countries involved	Seminars were open to participants from all Nordic countries.	B
Potential use of results and information	Results useful for seminar participants	B
Project results of adequate quality	The quality of project results seems to be good, as judged from web site abstracts.	B
Project in accordance with plans and budget	Project was carried out in accordance with plan and budget.	B

Cost-effectiveness of total budget	The NKS financial support has been 100,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 200,000 DKK. The cost-effectiveness is difficult to assess, but appears to be at the right level.	B
Relevance for authorities and others	Seminars provide opportunities for networking and competence building of relevance to authorities and organisations.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.3.5 Forest

The FOREST project was established to provide multidisciplinary knowledge on sampling of forest vegetation and soil, and publish this as a sampling guide. General and practical aims of the guide are to ensure the overall quality of data collected for determination of radionuclide content in various compartments of forests. The guide also aims at improving the documentation of sampling carried out in the field. Thereby the reliability of the estimation of radionuclide distribution in forests, model parameters derived from the data, and assessment of radiation exposure through radionuclides in forests will also be improved.

Objectives

The aim of the project is to compile knowledge and publish a guide-book for sampling in forests for radionuclide analysis.

Summary of evaluation

Title:	**Forest - Guidance for sampling in forests for radionuclide analysis and update of the Nordic forest radioecology network**
NKS funding:	225 000 DKK, continuing 2006-2007 (200 000 DKK for 2006)
Co-ordinator:	Elisabeth Strålberg IFE (NO)
Participants:	STUK (FI), METLA (FI), FOI (S), IFE (NO)
Evaluation material	Contract for 2005, status rerport 2005, draft of sampling guide
Published deliverables	None
Missing deliverables	Final version of sampling guide planned for publication in 2007.

A study on sampling methodology for forests has not earlier been carried by NKS or by the post-Chernobyl European Community funded projects in the field of nuclear energy. The draft of the sampling guide seems quite adequate, and also contains useful references to other relevant survey manuals.

Fulfilment of NKS-criteria

NKS evaluation criteria	**Fulfilment of NKS-criteria, Forest**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has the potential to build up competence and networking on sampling strategies in forest areas, an important ecosystem in Nordic countries.	B
The scientific and pedagogical merits of the project	Publication of the sampling guide gives the project very good pedagogical merits.	A

The application and scientific perspectives of the project	The project has a practical aim of ensuring good quality in radioecological field work, and is based on necessary scientific considerations. The scientific perspectives of the project appear to be limited.	C
At least three Nordic countries involved	Three Nordic countries involved in project	B
Potential use of results and information	The sampling guide will be useful to workers in radioecology.	B
Project results of adequate quality	Draft of sampling guide indicates that the final report will be of good quality.	B
Project in accordance with plans and budget	Project is continuing in 2006-2007, but seems to be going according to plan.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 225 000 DKK in 2005, with additional funding for 2006. Consequently, the results of should be judged against a total manpower effort of 450 000 DKK for 2005. Cost-effectiveness for compiling knowledge and writing the preliminary draft of the sampling guide seems to be average.	C
Relevance for authorities and others	The result of the project would (at the end) be relevant for the Nordic authorities engaged in radioecological monitoring as well as emergency preparedness and response.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.3.6 ECODOSES

The NKS B-programme EcoDoses project started in 2003 as collaboration between all the Nordic countries. This project may be seen as a natural continuation of work in the previous period (Bok 2.1 and 2.1.2 of NKS 35, NKS 66). In the period to be evaluated, work consists of several smaller projects planned on a yearly basis, with the possibility to base proposals for further work on the outcome of prior projects. The ECODOSES project will also be continued into the following period (2006-).

Objectives

The aim of the project is to improve the radiological assessments of doses to man from terrestrial ecosystems.

Summary of evaluation

Title:	**ECODOSES: Improving radiological assessment of doses to man from terrestrial ecosystems**
NKS funding:	1 010 000 DKK, continued in 2006 (280 000 DKK)
Co-ordinator:	Tone Bergan, NRPA (NO)
Participants:	NRPA (NO), GR (IS), STUK (FI), RISØ (DK), GU (S), FF (FI)
Evaluation material	Contracts for 2003, 2004, 2005, 7 semi-annual progress reports, NKS-98, NKS-110, Status report for 2005 (36s), NKS-123
Published deliverables	NKS-98: "EcoDoses: Improving radiological assessment of doses to man from terrestrial ecosystems", May 2004, 62p. NKS-110: "EcoDoses: Improving radiological assessment of doses to man from terrestrial ecosystems", July 2005, 88p. NKS-123: "EcoDoses: Improving radiological assessment of doses to man from terrestrial ecosystems. A status report for the NKS-B project 2005", April 2006, 39p.
Missing deliverables	Activity ongoing, final report to be submitted.

A 57-page report (NKS-98) describing results from the first part of the project was published in May 2004, with main emphasis on:

- Prediction of spatial variation in global fallout of 137Cs from atmospheric nuclear tests based on precipitation data and ^{137}Cs concentrations in air (based on original concept developed by Hvinden, T., Lillegraven, A., & Lillesæter, O. (1965). Precipitation as a cause of seasonal and latitudinal variations in radioactive fall-out. Nature, Vol. 206, No. 4983, 461-463.) Global fallout from nuclear weapons testing has been thoroughly assessed and modelled by appropriate international agencies (UNSCEAR 1982, 2000). In addition to presenting a valuable review of such data from a Nordic perspective, important findings of the ECODOSES project show that the global model does not take into account the relatively rapid deposition of radionuclides in the Northern Hemisphere originating from the Soviet tests in 1958. The deposited 137Cs in 1958 was also accompanied by high levels of ^{131}I. The UNSCEAR model was also found to significantly underestimate the annual deposition in Norway. The use of precipitation data to predict spatial variation in global fallout ^{137}Cs deposition was found to give reliable predictions for Nordic areas. Five out of six stations showed good agreement (-1 to +8 % deviation) between the precipitation-based estimates and the measured deposition.
- Contamination of radionuclides in milk.

A large amount of data on contamination of radionuclides in milk was collated from the Nordic countries and registered in an excel database. Traditionally, calculation of effective ecological half-life has been done using a single exponential decay regression, but the present work showed that better modelling can be achieved by using dual component regression. For 137Cs the effective ecological half- live seemed to be fairly equal for the different investigated regions - about 1 year for the fast component and 6 years for the long component. The effective ecological half- life for 90Sr is about 1 year for the fast component in all investigated regions while the long component varies between 4 and 12 years. This is a valuable approach that could be further refined. No interpretation of the two different half-life components is presented, nor are their relative contributions presented or discussed.

- Regional differences in 137Cs effective ecological half- lives in reindeer.

A new aspect introduced in the study of regional differences in 137Cs effective ecological half-lives in reindeer is the influence of grazing intensity on radiocaesium levels in the diet. The review emphasises that there are still important gaps of missing information in the understanding of reindeer radioecology, information that will help improving emergency preparedness relevant for a vulnerable indigenous population group at a regional level.

- Workshop on Radioecological Modelling in ECOSYS.

Thirteen persons from Nordic countries and Baltic stated participated in the workshop on radioecological modelling in ECOSYS, held at Risø National Laboratory, 10-11 September 2003. The workshop was based on use of the food and dose module (FDM) in the Danish ARGOS decision-support system which is intended for predicting consequences of short-term accidental releases of radioactivity. Valuable experience was gained. In order to assure reliability of the model applications it seemed important to specify proper assumptions of regional or local characteristics rather than using the standard model assumptions in order to further improve agreement between predicted and observed data.

Results from a continuation of the ECODOSES project was presented in a 85-page report published in July 2005 (NKS-110) focused on:

- A continuation of previous work with a better approach for estimating global fallout on a regional or national scale, based on a correlation between precipitation and deposition rates.

Valuable results are presented for other nuclides than ^{137}Cs, and a method for geographical mapping of predicted deposition was developed based on interpolation of precipitation data.

- Further extension of the EcoDoses milk database

focused on the post-Chernobyl period (1986-). Effective ecological half-lives of Cs-137 in milk from 12 regions were estimated. The fast component (T1) was about 1 year for all series (except Sandnessjøen in Norway), while the slow component (T2) was more variable (7-13 years) - and in some cases not applicable. Interesting studies were performed to use the UNSCEAR model to estimate the integrated transfer coefficients of 137Cs from wet deposition to cows milk from selected sites in three Nordic countries. The model relates the concentration of a radionuclide in a sample from a given year to the deposition rate of the radionuclide from precipitation in the given year and in the year before, and to the accumulated deposition from previous years.

- Determination of effective ecological half lives for fresh water fish from Nordic lakes.

An impressive amount of data on ^{137}Cs has been acquired for a number of fresh water fish species in selected lakes in Nordic countries. Concentration factors (Bq/kg in fish species / Bq/kg in lake water) provide useful summaries of data. The work seems somewhat fragmented, and will probably benefit from further systematic analysis.

- Investigate radioecological sensitivity for Nordic populations.

Important conclusions are drawn: The time-integrated aggregate transfer of 137Cs for the global fallout was 2-3 times higher than from Chernobyl debris for Swedish urban populations. For reindeer herders this difference is even more marked, with a factor of three to four higher time-integrated transfer factor of nuclear weapons fallout. For the the transfer of Chernobyl 137Cs debris the time-integrated transfer factor appears to be more than 25 times higher for reindeer herders in Sweden than for the urban reference groups. These findings are supported by values of committed effective dose coefficients (mSv/kBq m^{-2} ^{137}Cs deposition), but it is not specifically stated to what extent this represents revision of earlier established values.

- Food-chain modelling using the Ecosys- model, which is the underlying food- and dose module in several computerised decision-making systems. Valuable work has been done subsequent to the preliminary findings in 2004 that the FDM needed a change of a number of model assumptions and parameters from default values based on Central European conditions to those characteristic for Nordic countries, e.g. growing seasons, harvest times, crop yields, animal feeding regimes, human habits. Further generic inadequacies of the modelling system relate to dry deposition processes.

Main results from work in 2005 (Status report for 2005, NKS-123) are:

- Considerable variations in activity concentrations of 137Cs and 90Sr were observed between countries or regions due to factors such as different precipitation patterns, soil types and the inhomogeneity over Europe of Chernobyl fallout. The observed time trends indicate that the factors influencing the ecological half-life for 90Sr are not entirely the same as for 137Cs in the pasture – milk system.
- Deposition of 137Cs estimated based on precipitation data was found to show good agreement with measured values. The sum of the calculated deposition density from NWF and Chernobyl in western Sweden was compared to accumulated activities in soil samples at 27 locations.

Further work in EcoDoses will focus on the doses to man, by improving the fallout models and implementing the collected data into food and dose models. Focus will thus be on internal doses. Also work on the human data on ^{137}Cs body content will be further systemised and compared with the modelled data.

Fulfilment of NKS-criteria

The measurable results of the ECODOSES project for the period 2002-2005 are:

- NKS-98 report (57 pages)
- NKS-110 report (85 pages)
- NKS-123 (39 pages)

The total cost within the period 2002-2005 has been 1010,000 DKK, with additional funding of 280,000 DKK for continuation in 2006. Considering that involved participants contribute assumed equal funding, the cost seems considerable. Cost-effectiveness will, however, depend on the scientific value of the results obtained. For increased value, a further systematic analysis of the data, and their integration into larger high-quality databases and assessment projects such as ERICA would seem desirable.

NKS evaluation criteria	**Fulfilment of NKS-criteria, ECODOSES**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Pedagogical merits would be high if young candidates participate in project, but this is not known. Data of scientific merit were collected	B
The application and scientific perspectives of the project	Insufficient focus on integration of project with larger projects on the European or international level.	C
At least three Nordic countries involved	All five Nordic countries have been involved in the project.	A
Potential use of results and information	Insufficient emphasis on how to integrate results into larger surveys.	C
Project results of adequate quality	Project data presumably acquired under well-documented conditions and with adequate standardisation and quality assurance.	B
Project in accordance with plans and budget	Plans and budgets reviewed and revised annually, with a tendency to prolong ongoing projects.	C
Cost-effectiveness of total budget	The NKS financial support has been 1,010,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 2,020,000 DKK. The cost-effectiveness of the project appears to be somewhat low, i.e. high costs compared to the outcome of the project.	B
Relevance for authorities and others	Very valuable results for science and authorities were obtained.	A
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.3.7 INDOFERN

Objectives

The objective of the project was to search for new useful organisms accumulating effectively and specifically certain radionuclides in various Nordic ecosystems (terrestrial, fresh water, marine), and to compare their indicator value with those of the earlier known indicators. The aim of the project was to get more information about other long-lived nuclides than Cs-137 (90Sr, Pu and Am) and about the most abundant discharge nuclides from the nuclear power plants (e.g. 60Co). In

addition, the usability of different organs and tissues of the organisms as indicators should be studied.

Summary of evaluation

Title:	**Indofern - New indicator organisms for environmental radioactivity**
NKS funding:	3 030 000 DKK
Co-ordinator:	Erkki Ilus, STUK (FI)
Participants:	STUK (FI), NRPA (NO), IFE (NO), UMB (NO), GR (IS), RISØ (DK), LU (S), UF (FI)
Evaluation material	Contracts for 2002, 2003, 2004, 2005, 7 semi-annual progress reports, Summary report and 13 reports from partners to co-ordinator (chapters in NKS-140).
Published deliverables	Web-sites at participating institutions: http://www.stuk.fi/tutkimus/activities_and_projects/preparedness/en_GB/indofern/ http://www.ife.no/avdelinger/miljo_og_stralevern/prosjekter/indofern/view NKS-140: Proceedings of the Summary Seminar within the NKS-B Programme 2002-2005, 24-25 October 2005, Tartu, Estonia. April 2006, 184p (Electronic report). NKS-143: Proceedings of the Summary Seminar within the NKS-B Programme 2002-2005, 24-25 October 2005, Tartu, Estonia. August 2006, 184p (Printed report).
Missing deliverables	None

The study was expected to yield new data on the occurrence, transport and concentrations of many important radionuclides in potential candidates of indicator organisms concerning a wide scale of Nordic ecosystems. The choice of candidates should be based on references to literature concerning accumulation of radionuclides and stable elements to certain species or groups of organisms.

Work within the project has been co-ordinated and discussed in a series of project seminars (May 2002, May 2003, May 2004, April 2005) as well as being presented in the NKS-B summary seminar in Tartu, 24-25 October 2005. The proceedings report (NKS-140, NKS-143) from the latter seminar containing 13 presentations from the INDOFERN project is taken as the final report of the INDOFERN project.

At the beginning of the INDOFERN project, it was discussed in the project group, which term (bioindicator or indicator organism) should be used when studying the ability of organisms to exhibit presence and quantity of radionuclides in the environment. Bioindicators are commonly grouped into accumulation indicators and response indicators. Accumulation indicators store pollutants without any evident change in their metabolism. Response indicators react with cell changes or visible symptoms of damage when taking up even small amounts of harmful substances. Within radioecology, the term bioindicator is normally synonymous with accumulation bioindicator, i.e. organisms or organism communities that accumulate pollutants without any visible effects. The group decided to use the term *indicator organism*, without further definition of what was meant by this term, relative to the others. The search is for new useful organisms accumulating effectively and specifically certain radionuclides in various Nordic ecosystems (terrestrial, fresh water, marine), and to compare their indicator value with those of the earlier known indicators.

The idea in sampling was to take the samples from relatively small areas where the environmental factors (type of soil etc.) and the amount of radioactive deposition are likely homogenous, which

makes it possible to compare the indicator value of different organisms. Data were collected from about 170 organisms (species, family or group). The list of organisms consists of 49 mushrooms, 7 lichens, 5 mosses, 13 spore-bearing plants (*Pteridophytes*), 38 seed plants, 10 algae (including plankton and periphyton), 11 benthic animals, 15 fish species, 9 birds, 4 seals, 1 whale, the lynx and the polar bear. A majority of the organisms (98 species) represent terrestrial environment, 56 of them are from marine or brackish-water environment and 20 from the fresh water environment. The most extensively studied individual organisms were from the marine/brackish water environment, such as *Fucus vesiculosus* and *Mytilus edulis*. Large amounts of highly valuable data have been collected. However, it may seem that the measurement programs have to some extent been based more on what is feasible, rather than what is most needed. Thus, one of the progress reports points out that within the EU-project Framework for Assessment of Environmental Impact of Ionising Radiation (FASSET) it was recently concluded that particularly radiological data on marine mammals are lacking. Nevertheless, only 5 such animals were sampled in the INDOFERN project. Results are reported on radionuclide concentrations in indicator organisms (Bq/kg dry or wet weight), as well as on aggregated transfer factors (Bq/kg per Bq/m^2 deposition) or concentration factors (Bq/kg per Bq/kg water). The measurements vary somewhat with respect to protocol. Thus, in some cases marine samples have been collected without at the same time collecting representative water samples, whereas in other cases both types of data were collected, thus allowing reliable calculations of concentration factors. Collection of systematic time series of radionuclide concentrations in sea water at chosen locations would establish an important source function for studying accumulation of radionuclides in various marine species at the same sites. This project should be co-ordinated or integrated into larger programmes such as ERICA.

Fulfilment of NKS-criteria

The INDOFERN project is the largest project under the NKS-B programme for the 2002-2005 period, requiring 30% (3 million DKK) of total NKS-B programme funding. Considering that assumed equal funding is contributed by involved participants, the cost seems considerable. Much cost-intensive fieldwork has, however, been carried out within the project. Since the final report of the project is in form of a seminar proceedings, it is difficult to assess the final value of the project.

NKS evaluation criteria	Fulfilment of NKS-criteria, Indofern	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework in which radioecology is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to maintain and extend the competence on radio-ecological data acquisition, analysis and modelling.	B
The scientific and pedagogical merits of the project	Pedagogical merits would be high if young candidates participate in project, but this is not known. Data of scientific merit were collected	B
The application and scientific perspectives of the project	Insufficient focus on integration of project with larger projects on the European or international level.	C
At least three Nordic countries involved	All five Nordic countries have been involved in the project.	A
Potential use of results and information	Vast amounts of data have been collected, with corresponding potential usefulness, but end-use of the results seems uncertain.	C
Project results of adequate quality	Project data seem to be collected without a strict protocol.	D
Project in accordance with plans and budget	Plans and budgets reviewed and revised annually. There seems to be a lack of stringency in the planning of fieldwork.	D
Cost-effectiveness of total budget	The NKS financial support has been 3,030,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 6,060,000 DKK. Fieldwork entails extra cost. The cost-	D

	effectiveness of the project is difficult to assess since end-use of the results is uncertain.	
Relevance for authorities and others	Valuable results for science and authorities were obtained.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B-**	

2.3.8 General evaluation of radioecology projects

The main relevance of NKS radioecological projects is to establish reliable data for use in decision support systems for handling of emergency situations. For this purposes it is important that the work performed is well planned and integrated into larger frameworks. Nordic countries possess significant competence in the above-mentioned area, as exemplified by the ARGOS decision support system versus the RODOS system developed by EU, and well-established time-series of a number of radioecological analyses.

From the published reports of NKS-projects in this field, it is not always clear how the results will be utilised in a systematic manner to further strengthen the expertise in the area of radioecology. For improvement of decision support systems, an initial critical analysis should first be performed on what type of data is most needed to strengthen system performance. Subsequently, such data should be acquired through focused project work. INDOFERN is by far the largest NKS project in radioecology, requiring 30 % of total NKS-B project funding. Amongst the plethora of species and ecosystems that could be analysed, it would seem important to concentrate on a limited number of

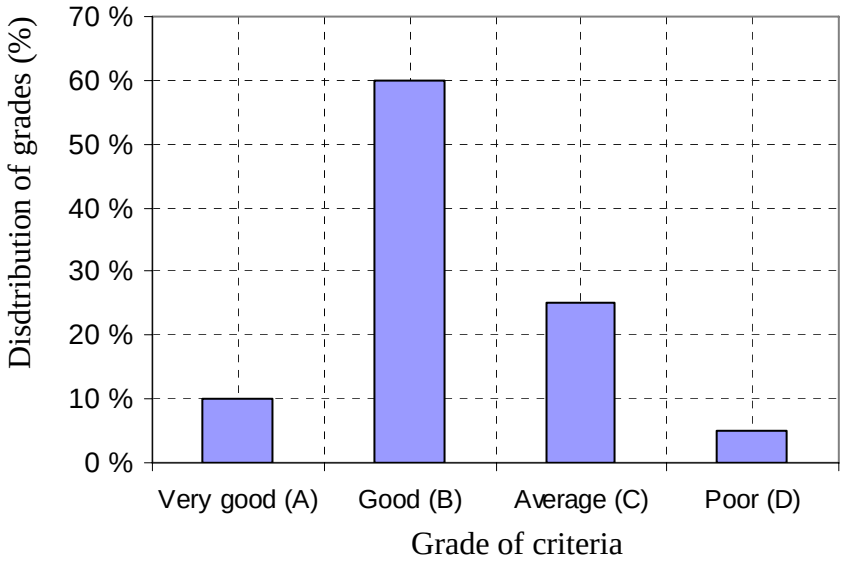


Figure 18. Distribution of grades for ten evaluation criteria over the six evaluated radioecology projects (7 radioecology projects in total)

species chosen as representatives of various ecosystems of special interest and relevance for Nordic

countries. The effort should then be focused on systematic, long-term monitoring of the chosen species. Such systematic measurement programmes should be implemented in collaboration with university personnel to encourage student recruitment to the area. Yearly field work and subsequent sample analyses could be run in parallel between student projects and professional work, where the latter would provide student advice and guidance but also be responsible for the official measurement results. Such collaborative projects with university groups could in addition to the fixed measurement programme also pursue more explorative studies, e.g. on the added value of analysing several organs from the selected species as part of biodistribution studies.

A crude averaging of the overall quality of radioecology projects has been performed by adding (over all the projects and evaluation criteria) scores of the same grade (from very good to very poor) as shown in figure 18. The results indicate that the "average overall quality" of the six evaluated

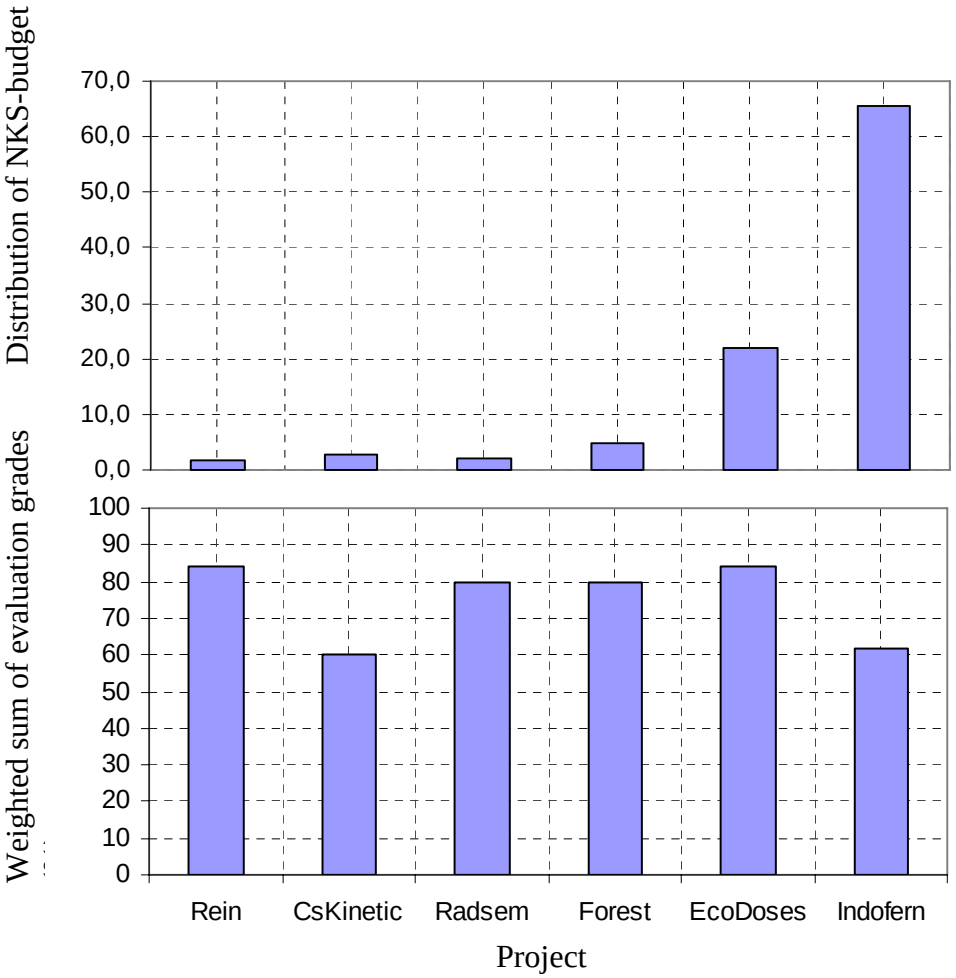


Figure 19. Relative distribution of the NKS-budget and weigthed sum of grades for each of the six evaluated radioecology projects (7 radioecology projects in total).

radioecology projects in general is quite satisfactory as 70% of all scores fall within the categories "very good" and "good". Despite the satisfactory average score, individual differences in 'quality' exist.

Radioecology projects represent a total cost of 4,620 kDKK, with ECODOSES and INDOFERN being the two largest, representing 21% and 65 % of the radioecology project costs, respectively, as shown in the upper panel of figure 19.

To have an indication for the alleged differences in 'quality' between individual radioecology projects the sum of grades of the same category (*A, B, C* etc.) over the ten evaluation criteria has been weighted using the same weighting algorithm as for measurement technology projects (see chapter 2.2.10):

$$\overline{G} = 2^4 \cdot N_A + 2^3 \cdot N_B + 2^2 \cdot N_C + 2^1 N_D + 2^0 \cdot N_E$$

The weighted sum of evaluation grades, $\overline{G}$, for each of the radioecology projects is shown in the lower panel of figure 19.

Challenges for the future will be to:

- Integrate results efficiently into knowledge data bases and decision support systems
- Stronger focus towards
  - the needs of radiological input to decision support systems
  - systematic measurement programmes for a few selected organisms of combined Nordic and EU interest and relevance.
- Include to a larger extent university personnel and graduate students in projects of academic interest and relevance.

2.4 Emergency preparedness

The aim of the NKS-B programme is to strengthen radiological emergency preparedness in the Nordic countries. Apart from activities directly targeted at emergency preparedness also activities in related areas such as radioecology and effective communication and information management should be included and be focused on emergency preparedness related questions. Two main aspects have been given the highest priority:

(1) Maintaining and building up *competence*, and

(2) Maintaining and building *close informal Nordic networks* between scientists in emergency preparedness related disciplines.

In the guidelines for the NKS-B programme for the period 2002 - 2005 overall considerations on future efforts have been proposed. They include issues like decision support systems, consequence analyses, exercises, measurement strategies and methods as well as information strategies. Some specific project areas have been identified:

- evaluating existing decision support systems with respect to further development, validation and harmonisation of such systems
- performing exercises with a longer time perspective including, *e.g*. contaminated foodstuffs
- performing studies on the consequences of accidents at nuclear power plants in Western Europe
- developing manuals for application in accident situations
- developing optimum sampling and measurement strategies on environmental samples
- developing portable field measurement systems

- developing measurement protocols for characterisation of fallout in urban areas as basis for decisions on countermeasures
- development of models for estimation of doses to urban populations
- further development of Nordic collaboration on information in emergency situations

In the following evaluation the projects have been judged firstly against how well they fulfil the aims of the fields, and secondly against the ten criteria that emerged from the interpretation of the guidelines set out by the NKS Board (see Appendix 1).

2.4.1 URBHAND

Phase 1 of the project URBHAND has been performed in the period 2004 - 2005. The project will continue during 2006 - 2007 in a phase 2 where national end-user fora will be set up in the Nordic countries to discuss and review the handbook. In addition, an exercise will be formulated in which regulators and decision-makers can test the handbook with the aim of producing a final handbook at the end of 2007.

Objectives

The objectives of the URBHAND project have been formulated in 'Call for Proposals' and they are summarised below:

- The overall objective of the project was to create a handbook designed to assist Nordic decision-makers in the remediation of contaminated inhabited areas in the event of a severe nuclear accident. The handbook should address the special Nordic perspective and utilise state-of the-art knowledge as basis for the decision on different remediation strategies.
- The handbook should describe an easily applicable methodology for calculation of long-term doses in an inhabited environment, including the newest radionuclide transfer data in dose calculations.
- The importance of measurement strategies, systems and equipment for the purpose of countermeasure optimisation should be described. Flow charts or other chart representations should be suggested to help decision-makers through crucial steps of the planning.
- The handbook should focus on the radionuclide ^{137}Cs released in major nuclear accidents. Also the specific problems with the detonation of a so-called 'dirty bomb' dispersion device in an inhabited area should be dealt with.
- A number of countermeasures that would be considered to be particularly appropriate for Nordic kitchen garden areas should be described, considering the optimisation principles introduced by ICRP 82.

Summary of evaluation

The deliverables and funding of phase 1 of the project are summarised in the table below. Phase 2 is planned for in the period 2006 - 2007.

Title:	**URBHAND - Decision support handbook for remediation of contaminated inhabited areas**
NKS-funding:	205,000 DKK (2004), 205,000 DKK (2005), 410,000 DKK (2006 - 2007)
Co-ordinator:	Kasper G. Andersson, Risø National Laboratory (DK)
Participants:	STUK (FI), IFE (N), SLU (S)
Evaluation materials:	Project proposals for 2004 and 2005, progress reports for 2004 and 2005, Handbook

Published deliverables:	Version 1 of Handbook for end-user discussion Paper presented at the NSFS ordinary meeting in 2005 in Rättvik, Sweden
Missing deliverables:	Final Handbook (to be finalised in 2007)

Central parts of the handbook contain data for remediation techniques that can be used in urban environments and simple calculation schemes for assessing external doses from deposited radionuclides on different types in an urban environment, *e.g.* walls, roofs and grass/soil/trees. Together with the remediation data described in Chapter 4, the dose calculation schemes can be used to assess the avertable doses for selected remediation strategies.

The handbook addresses both nuclear and radiological accidents including malicious radionuclide dispersion devices ('dirty bombs'). Such a device might be 'loaded' with α- or pure β-emitters such as ^{239}Pu or ^{90}Sr, and, consequently, in phase 2 of the project, Chapter 5 might be extended with tables containing dose conversion factors for such radionuclides to assess inhalation dose rate from resuspended material for given values of the resuspension factor.

Chapter 9 of the handbook is quite important focusing on the process on how to select an optimised remediation strategy. However, this important chapter needs to be tightened and several illustrative examples might be included. Flow charts and other graphical illustrations would be important together with these examples to illustrate the process of justification and optimisation of remediation strategies. Of special importance is an illustration of how the social factors dealt with in Chapter 8 should be included in the justification/optimisation process.

In the introduction of Chapter 9 a somewhat more detailed elaboration of the ICRP/IAEA recommendations on remediation of contaminated areas would have been appropriate also because the use of the ICRP 82 in the optimisation process was one of the objectives of the project. Reference levels of 10 mSv/a and 100 mSv/a are recommended both in ICRP No. 82, IAEA-TECDOC-987 and the IAEA Safety Requirements No. WS-R-3. In the application example in chapter 9 the three relevant remediation options seem to be unjustified on pure cost-benefit considerations using the cost data presented and not including social factors.

In the phase 2 of the URBHAND project it should be considered if some of the results of the EMARAD project, *e.g.* material on measurement strategies and monitoring systems as well as material on urban dispersion calculations, could be transferred and integrated into the Handbook as a supplement to the already existing material.

Fulfilment of NKS-criteria

The measurable results of the URBHAND-project during the project period 2004 - 2005 are:

- Project contract and project proposals
- A draft handbook for end-user discussion with nine chapters in 124 pages
- Two progress reports (2004 and 2005)
- A paper at the NSFS ordinary meeting in 2005 in Rättvik, Sweden

The project results information seems to have been rather scarce during the project period. It could be advantageous to continue the project in the new NKS-programme; if so, the handbook should be extended to include methodologies on justification/optimisation of remedial measures in urban environments.

The results of the URBHAND-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	Fulfilment of NKS-criteria, URBHAND	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework within which "developing manuals for application in accident situations" is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to extend the competence on the use of clean-up data from full-scale experiments in the former USSR.	C
The scientific and pedagogical merits of the project	The scientific merit of the project appears to be limited. The pedagogical merit of the project is the collection of a large amount of data in a single handbook.	C
The application and scientific perspectives of the project	The handbook has the potential of being useful for the Nordic emergency preparedness community. The handbook includes the latest scientific data, based on both theory and experiments. The scientific perspective would be the incorporation of an overall justification/optimisation procedure that would allow the inclusion of social attributes.	B
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	The results and the information in the handbook are relevant in nuclear and radiological accident situations where urban environments have been contaminated. The handbook could be made more user-friendly, e.g. by moving much of the background text to appendices. Many technical details are "submerged" in the text, e.g. shorter calculations using figures extracted from the tables. Such calculations and results could with advantage be presented as examples instead of being integrated in the text and a more 'handbook-like' text would appear. Also the use of flow charts in the examples would be beneficial.	C
Project results of adequate quality	The quality of the results is adequate but the handbook could be made somewhat more user-friendly in phase 2 of the project.	C
Project in accordance with plans and budget	The project is in accordance with plans and budget although minor parts of the objectives are not met.	B
Cost-effectiveness of total budget	The NKS financial support of phase 1 of the project has been 410,000 DKK. Consequently, the results of phase 1 of the project should be judged against a total manpower effort of 820,000 DKK. The cost-effectiveness appears to be somewhat low, i.e. high costs compared to the outcome of the project.	C
Relevance for authorities and others	The result of the study and the handbook are relevant for authorities being important participants in the decision-making process.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B–**	

2.4.2 UrbContSem

An international conference entitled "Radioactive Contamination in Urban Areas" was held at Risø National Laboratory in the period 7 - 9 May 2003 with financial support from NKS.

Objectives

The conference was arranged in the light of the experience gathered after the Chernobyl accident that the urban environment has not received the same attention in radioecology as has the agricultural environment, and that data are needed to ensure justified and optimised remediation strategies for urban areas. The objectives of the conference were:

- To create a forum for presentation of new knowledge on contamination and decontamination of inhabited areas.
- To provide a basis for a much needed improvement of preparedness strategies for inhabited areas in Europe.
- To pinpoint areas where further investigations are needed.

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**UrbContSem - Conference on urban contamination**
NKS-funding:	200,000 DKK
Co-ordinator:	Jørn Roed, Risø National Laboratory (DK)
Participants:	STUK (FI), IFE (N), SLU (S), SSI (S)
Evaluation materials:	Conference program, abstracts and NKS web site
Published deliverables:	All abstracts, slides and posters presented are displayed on the NKS web site: www.nks.org/nordisk/B-delen/resultater.htm Journal of Environmental Radioactivity, Volume 85, Issues 2-3, Pages 151-388 (2006), Radioactive Contamination in Urban Areas, Edited by Kasper G. Andersson
Missing deliverables:	None

In the period 7 - 9 May 2003, a Conference on Radioactive Contamination in Urban Areas was held at Risø National Laboratory to provide a forum for presenting new knowledge of relevance to urban contamination. A total of 53 presentations were given at the conference including five invited presentations. The presentations provided many interesting and valuable conclusions, but also left many important questions open, clearly demonstrating the needs for further research. A separate session at the conference was devoted to the problems of contamination of natural recreational areas and forests frequently used by urban populations. A special issue of Journal of Environmental Radioactivity contains 17 selected papers elaborating on presentations given at the conference and dealing with different aspects of urban contamination.

In recent years, the possibility of a very different type of radiation incidents has attracted attention, *e.g.* detonation of malicious radionuclide devices in urban areas. However, available data to perform detailed analyses of such consequences of contamination in urban areas are relatively sparse. A major conclusion from the conference was that extrapolation from the Chernobyl accident would not apply to such different types of contaminating scenarios.

Fulfilment of NKS-criteria

The measurable results of the UrbContSem-project are:

- Project contract and project proposal
- The conference on Radioactive Contamination in Urban Areas held at Risø National Laboratory 7 - 9 May 2003

- The publication of papers from the conference in the Journal of Environmental Radioactivity, Volume 85, Issues 2-3 (2006)
- The publication of all abstracts, slides and posters on the NKS web site

The results of the UrbContSem-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, UrbContSem**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework within which "development of models for estimation of doses to urban populations" is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to Nordic network building and identified areas for further competence building.	B
The scientific and pedagogical merits of the project	The pedagogical merit of the project is the high quality papers presented. The scientific merit is the identification of the further research needs to make urban dispersion modelling more reliable.	B
The application and scientific perspectives of the project	The conference revealed the need for more model data, especially on dry deposition, deposition under foggy conditions, weathering and resuspension as well as a large discrepancy between results from different urban dispersion models. The perspectives for further research might be oriented towards the application of models on the malicious radionuclide dispersion devices in urban environments.	B
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	The conference gave many useful results and the application potential of many of the presented papers is high.	B
Project results of adequate quality	The quality of the presentations at the conference was high and 17 papers from the conference have been published in Journal of Environmental Radioactivity.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 200,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 400,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	The results of the presentations are relevant for both authorities and other professionals, especially regarding the importance of reliable consequence assessment models for contaminated urban areas.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.4.3 NucVess

The project NucVess has been performed in the period 2004 - 2005. The aim of the project was to reduce the gap between the desirable and the actual knowledge on Russian marine reactors and their fuel through a study of all available open sources on this subject. The focus has been on source term data, based on information on actual design and earlier accidents with Russian naval vessels.

Objectives

The objectives of the NucVess-project were:

- To evaluate all available design information for marine reactors, complete studies of release fractions for specific accidents (LOCA, criticality accidents during re-fuelling/de-fuelling) with releases to air and/or sea
- To examine the possibility for re-criticality in spent fuel configurations on shore (*i.e.* in storage at former naval bases) for PWR marine reactors and in spent removal blocks from liquid metal reactors
- To improve the overall ability of the relevant Nordic authorities to perform impact assessments for accidents involving Russian naval vessels and spent fuel
- To prepare two reports: (1) Russian Nuclear Power Plants for Marine Applications and (2) Source Term Evaluation for Severe Accidents with Russian Nuclear Power Plants for Marine Applications

Summary of evaluation

The deliverables and funding of the NucVess-project are given in the table below.

Title:	**NucVess - Impact assessment of accidents with nuclear powered vessels - analysis of release mechanisms and source term composition**
NKS-funding:	100,000 DKK (2004), 240,000 (2005)
Co-ordinator:	Ole Reistad, Norwegian Radiation Protection Agency, Poul Ølgaard, Risø National Laboratory
Participants:	NRPA (N), Risø (DK)
Evaluation materials:	NKS-138 and NKS-139
Published deliverables:	NKS-138: Russian Nuclear Power Plants for Marine Applications, April 2006, 92 pp. NKS-139: Inventory and Source Term Evaluation of Russian Nuclear Power Plants for Marine Applications, April 2006, 70 pp.
Missing deliverables:	None

NKS-138 describes the development of and the present state of the nuclear vessel classes and generations of the Russian nuclear navy, of the Russian nuclear icebreaker classes and of the Russian nuclear submarine designs. The different types of Russian marine reactors are described and data for Russian nuclear naval vessels - both submarines and surface vessels for military and civilian purposes - are listed in detail in an Annex. Also Russian nuclear marine bases and shipyards are listed in an Annex. Finally, criticality and loss of cooling accidents that have involved Russian nuclear vessels are reviewed and rather detailed accidents descriptions are presented in an Annex.

NKS-139 deals with source terms for accidents at nuclear submarines. The report focuses on the different factors contributing to the source term for accidents at Russian naval reactors and their spent fuel and presents information on the activity inventory in Russian naval reactors and source terms for criticality accidents, loss-of-cooling-accidents and sunken submarines. The report also includes estimations of the radiological consequences in the marine environment after potential releases of radionuclides from the submarine Kursk.

The reports conclude that loss-of-cooling accident may have serious consequences to the submarine crew since the whole submarine may be contaminated, but it will result in little activity release to the environment. The sinking accidents will leave a significant amount of activity at the bottom of the sea, but its release to the environment will be very slow and therefore result in very small activity concentrations in the surrounding water. Spent fuel accidents may well give rise to important contamination of areas of the naval bases, but its effect will be local. The only exception

is a criticality accident with spent fuel, but this type of accident is not very probably, since safe geometries are used in connection with spent fuel handling

Both reports contain valuable material that can be used in the impact assessment of accidents involving Russian naval vessels and spent fuel. There is some overlap between the content in the two reports and it might be considered to combine the two reports into one report. It should also be considered to include the major findings of the present project into the NKS-B project "Knowledgebase" the scope of which has been to prepare a base of knowledge regarding possible nuclear threats in the vicinity of the Nordic countries.

Fulfilment of NKS-criteria

The measurable results of the NucVess-project during the project period 2004 - 2005 are:

- Project contract and project proposal
- NKS-138: Russian Nuclear Power Plants for Marine Applications
- NKS-139: Inventory and Source Term Evaluation of Russian Nuclear Power Plants for Marine Applications

A periodic update of the project results might be considered if new designs of nuclear powered vessels are launched.

The results of the NucVess-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	Fulfilment of NKS-criteria, NucVess	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework within which "performing studies on the consequences of accidents at nuclear power plants in Western Europe" is an identified area.	B
Nordic competence and network building and maintenance	The competence network building and maintenance is limited due to the relatively narrow topic and to the limited number of participants.	C
The scientific and pedagogical merits of the project	The scientific merit of the project appears to be rather low. The pedagogical merit is the collection of a large collection of detailed technical data on Russian nuclear powered vessels. Furthermore, the project has contributed as part of a PhD-education of a young scientist.	B
The application and scientific perspectives of the project	The scientific perspectives of the project are judged to be rather limited. The results can be applied in different information databases.	C
At least three Nordic countries involved	Only two Nordic countries (N + DK) have been involved in the project, which can be justified considering that particularly Norway is exposed to the threat from Russian nuclear powered vessels.	C
Potential use of results and information	The results of the project are relevant in accident situations involving Russian nuclear powered vessels. The potential use of the project results and information can be increased by integrating the results in the website database "Nuclear threats in the vicinity of the Nordic Countries" that has been built in another NKS-B project "Knowledgebase".	C
Project results of adequate quality	The quality of the project results is judged to be on the average.	C
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the NucVess project has been	D

	340,000 DKK (100,000 DKK + 240,000 DKK). Consequently, the results of the project should be judged against a total manpower effort of 680,000 DKK. The cost-effectiveness appears to be rather low, i.e. high costs compared to the outcome of the project.	
Relevance for authorities and others	The results of the project are relevant for the Nordic authorities, especially the Norwegian authorities, as the possible nuclear threats from Russian nuclear powered vessels are primarily directed against Norway.	C
Evaluation grade	**B–**	
A (very good), B (good), C (average), D (poor), E (very poor)		

2.4.4 NordRisk

The NordRisk project was started in 2005 and will be finalised in 2006. The main focus of the project is on atmospheric dispersion and meteorology and a general aim of the project is to build up competence on probabilistic risk assessment. The activity will strengthen and expand a multidisciplinary network among Nordic modellers, radiologists, nuclear-safety experts, and decision-makers. The project has been performed in connection with the NKS-B MetNet project.

Objectives

The objectives of the NordRisk-project were/are:

- to provide a simple and practical method for assessing and comparing nuclear risks due to atmospheric transport deposition from accidental releases;
- to build an atlas of long-range atmospheric dispersion and deposition following a number of release scenarios following hypothetical nuclear accidents in Northern Europe;
- to supplement this atlas with practical tools for rapid risk assessment for other (user defined) radionuclide release scenarios.

The project aims at supplying users and decision makers with practical means for risk and vulnerability mapping, considering, *e.g.*, what geographical areas are at risk from nuclear accidents.

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**NordRisk**
NKS-funding:	180,000 DKK (2005), 260,000 DKK (2006)
Co-ordinator:	Bent Lauritzen, Risø National Laboratory (DK)
Participants:	Risø(DK), DMI (DK), NRPA (N), SSI (S)
Evaluation materials:	Project proposals for 2005 and 2006, progress report 2005, Status report of October 2005, NordRisk web site: http://www.risoe.dk/nuk/emergency/NordRisk.htm
Published deliverables:	Project presentations on NordRisk web site Probabilistic risk assessment for long-range atmospheric transport of radionuclides, Paper submitted to Journal of Environmental Radioactivity, Special Issue, The 2nd International Conference on Radioactivity in the Environment & the 6th International Conference on Environmental Radioactivity in the Arctic and the Antarctic, 2-6 October 2005 in Nice, France
Missing deliverables:	Atlas of long-range atmospheric dispersion and deposition following release scenarios following hypothetical nuclear accidents in Northern Europe PC-based software tool for rapid assessment of average transport patterns with graphical interface and the allowance for user-defined parameter values

The project has at the time of evaluation not been fully completed. The results presented at international conferences and papers submitted to peer-reviewed international journals indicate, however, that both the atlas and the software tool will be valuable tools for the end-users being the Nordic emergency management authorities. In addition, there seems to be a potential for futher development of the prepared methodology in the NordRisk project.

Fulfilment of NKS-criteria

The measurable results of the NordRisk project during the project period 2005 - March 2006 are:

- The NordRisk web site
- Project contract and project proposals of 2005 and 2006
- Project status reports of October 2005 and December 2005
- Presentations at two international conferences
- Paper submitted to Journal of Environmental Radioactivity

The NordRisk project continues in 2006 and the project results can therefore not be evaluated fully at this time. The project results so far have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	Fulfilment of NKS-criteria, NordRisk	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework within which consequence analyses of nuclear accidents is an identified area.	B
Nordic competence and network building and maintenance	The project has contributed to build up competence on probabilistic risk assessment. The project has strengthened the multidisciplinary network among Nordic modellers.	A
The scientific and pedagogical merits of the project	The scientific merit of the project is the disclosure of the need for further development of simplified methods for probabilistic risk assessments. The pedagogical merit of the project is the atlas of long-range atmospheric dispersion and deposition together with PC-based software tool for rapid assessment of average transport patterns.	A
The application and scientific perspectives of the project	The results of the project are applicable for emergency preparedness planning with regards to accidental releases from nuclear power plants and other atmospheric releases of radioactive materials. The methodology for simplified probabilistic risk assessments may be further developed to include regional and climatological variations in the atmospheric dispersion and deposition potential.	A
At least three Nordic countries involved	Three Nordic countries and a Russian institute have been involved in the project.	B
Potential use of results and information	The potential end-users of the project results are the Nordic emergency management authorities. The project will give users and decision-makers practical tools for mapping which areas are vulnerable and at risk from nuclear accidents with atmospheric releases of radioactive materials.	B
Project results of adequate quality	The quality of the project results can at present not be judged adequately as the final product will be delivered during 2006. If the results are of similar quality as of the previous deliverables they are expected to be of high quality.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget. The final versions of the atlas and the practical PC tool will be delivered during 2006 and has therefore not been evaluated.	B
Cost-effectiveness of total budget	The NKS financial support has been 180,000 DKK in 2005.	B

	Consequently, the results of the project should be judged against a total manpower effort of 360,000 DKK. The cost-effectiveness appears to be at the right level.	
Relevance for authorities and others	The result of the project is relevant for both authorities and others engaged in the assessment of the consequences of a nuclear accident with long-range atmospheric dispersion and deposition of radioactive materials.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B+**	

2.4.5 MetNet

The MetNet project started in 2003 and will be finalised in 2006. The project aims at creating a network of Nordic meteorological services engaged in nuclear preparedness and response through operational real-time calculations of long-range atmospheric dispersion and deposition of radioactive materials released to the atmosphere in nuclear accidents.

Objectives

The objectives of the MetNet project were/are:

- to harmonise a general layout of the MetNet password protected homepages at each Nordic Meteorological Institute and to include graphical software that might be different for the different institutes;
- to harmonise the output of the different dispersion models, including graphical plots and data files to be made available to the Nordic emergency management authorities from the MetNet homepages;
- to perform at least two nuclear emergency modelling exercises in connection to suitable exercises performed by the Nordic emergency management authorities or other international exercises;
- to prepare for an operational continuation of the MetNet after 2006;
- to perform an evaluation of the performed real-time exercises with regard to both scientific aspects and presentations on the Web.

The MetNet network aims at being a forum for exchange of scientific information concerning atmospheric dispersion modelling as well as being a Nordic Web-based backup facility for long-range atmospheric dispersion calculations and for exchange of real-time and forecast model results.

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**MetNet**
NKS-funding:	190,000 DKK (2003), 200,000 DKK (2004), 200,000 DKK (2005), 200,000 DKK (2006)
Co-ordinator:	Jens Havskov Sørensen, DMI (DK)
Participants:	DMI (DK), NMI (N), SMHI (S), FMI (FI), IMO (IS)
Evaluation materials:	Project proposals, Project contract, Progress report 2004, Revised status report 2004, Minutes of project meeting in Reykjavik 2004, Reports on exercises
Published deliverables:	MetNet web sites at the Nordic Meteorological Institutes Report of MetNet real-time exercise 2.1, 2003 Report of MetNet exercise 3, Havsörn, 2004

	Report of MetNet exercise 4, Vulcanic eruption in Mt. Grimsvötn in Iceland, 2004
Missing deliverables:	Final Project Report, project continues during 2006

The project has at the time of evaluation not been fully completed. The results of the project so far are primarily the outcome of three exercises of which two dealt with nuclear accidents at a Swedish and a Finnish nuclear power plant whereas the third exercise dealt with a vulcano eruption in Iceland.

The experience from the exercises showed a great value of having an Nordic network for real-time atmospheric transport calculations and that the NKS-MetNet partners can act as an operational unit in case of an emergency situation. Within only a few hours qualitative good results can be produced from the institutes.

Fulfilment of NKS-criteria

The measurable results of the MetNet project during the project period 2003 - March 2006 are:

- Project contract, project proposals and progress/status reports
- Minutes of a project meeting
- The MetNet web sites at the Nordic Meteorological Institutes
- Reports on three MetNet exercises

The MetNet project continues in 2006 and the project results have therefore not been fully evaluated at the deadline for the evaluation report. The project results information seems to have been rather scarce during the project period. However, the project fits well with the NKS-priority of building close informal Nordic networks between scientists in emergency preparedness related disciplines. The project results have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, MetNet**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework within which consequence analyses of nuclear accidents is an identified area.	B
Nordic competence and network building and maintenance	The project has resulted in a Nordic network that can be very useful in a nuclear emergency situation in delivering results to the end-users/decision-makers. The network will continue after 2006 within the Nordic meteorological institute's co-operation NORDMET.	B
The scientific and pedagogical merits of the project	The scientific merit of the project appears to be limited. The pedagogical merit of the project is that the MetNet partners can act as an operational unit for real-time atmospheric transport calculations in case of an emergency situation.	C
The application and scientific perspectives of the project	The created network is applicable at the operational level in emergency situations and the intention is that it should act also as a forum for exchange of scientific information concerning atmospheric modelling to be used in emergency situations.	B
At least three Nordic countries involved	Five Nordic countries have been involved in the project.	A
Potential use of results and information	The potential end-users of the network are the Nordic emergency management authorities. The network can supply end-users and decision-makers valuable input for assessing the consequences of nuclear accidents.	C
Project results of adequate quality	The quality of the project results can at present not be judged adequately as the final product will be delivered in 2006. If the	C

	quality of the final product will be similar to that of previous deliverables it is expected to be average.	
Project in accordance with plans and budget	The project seems to be in accordance with plans and budget.	C
Cost-effectiveness of total budget	The NKS financial support has been 590,000 DKK in the three year period 2003 - 2005. Consequently, the results of the project should be judged against a total manpower effort of 1,180,000 DKK. The cost-effectiveness of the project appears to be rather low, i.e. high costs compared to the outcome of the project.	C
Relevance for authorities and others	The result of the project is relevant for both authorities and others engaged in the assessment of the consequences of a nuclear accident with long-range atmospheric dispersion and deposition of radioactive materials.	C
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B–**	

2.4.6 Knowledgebase

The Knowledgebase project started in 2002 and was finalised in 2003. The purpose of the Knowledgebase project was to continue the cross-disciplinary study SBA-1 "Base of knowledge" in the NKS research program 1998 - 2001 regarding possible nuclear threats in the vicinity of the Nordic countries. The main task of the project was to expand and envelope this database. The project has focused on potential events at nuclear installations and the consequences for the Nordic countries, especially with regards to vulnerable food chains, doses to man, environmental contamination and emergency preparedness systems. The geographical area dealt with includes North-west Russia and the Baltic states and the nuclear installations investigated are nuclear power plants, ship reactors and storage and handling of used fuel and radioactive waste.

Objectives

The objectives of the Knowledgebase project were:

- to continue the fact finding for the 'Base of knowledge' on nuclear threats in the vicinity of the Nordic countries;
- to work with other NKS-projects to establish a Nordic network for information exchange on scientific questions concerning nuclear threats;
- to produce an information system that takes care of the information in the 'Base of knowledge';
- to present a new version of the 'Base of knowledge' for the emergency authorities.

The main goal of the project was better information preparedness in the Nordic countries through use of modern technology, and with that better emergency preparedness and response and better public information.

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**Knowledgebase**
NKS-funding:	150,000 DKK (2002 + 2003)
Co-ordinator:	Inger Margrethe H. Eikelmann, NRPA (N)
Participants:	NRPA (N), SSI (S), SKI (S), STUK (FI), Beredskabsstyrelsen (DK), Geislavarnir rikisins (IS)

Evaluation materials:	Project contract, Project proposal, Final Project Report
Published deliverables:	Knowledgebase web site: http://nrk.svanhovd.no/ NKS-121: Nuclear Threats in the Vicinity of the Nordic Countries, April 2006, 9 pp.
Missing deliverables:	None

Compared to the previous NKS project SBA-1 in the period 1998 - 2001 the present project has expanded the geographical area of the nuclear threats and new information has been included in the 'Base of knowledge'. Also the literature database has been expanded.

The main task for the project has been the expansion of the database. This will be a continuous process which extends beyond the end of this project in order to have an operating and updated database also in the future. In the present project arrangements have been made that can take care of the database in the future.

Fulfilment of NKS-criteria

The measurable results of the Knowledgebase project during the project period 2002 - 2003 are:

- Project contract and project proposal of 2002
- Knowledgebase web site
- NKS-121: Nuclear Threats in the Vicinity of the Nordic Countries, April 2006

The project results have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	Fulfilment of NKS-criteria, Knowledgebase	Grade
Project falls within NKS-B framework	The project falls within the NKS-B framework within which "developing manuals for application in accident situations" is an identified project area.	B
Nordic competence and network building and maintenance	The project has contributed to extend the knowledge of the nuclear threats to the Nordic countries and has established a network for Nordic information exchange.	C
The scientific and pedagogical merits of the project	The scientific merit of the project appears to be rather low. The pedagogical merit is the collection of a large collection of different technical data, e.g. on Russian nuclear power installations.	C
The application and scientific perspectives of the project	The results of the project are applicable to assess the threats to the Nordic countries from surrounding nuclear installations. The scientific perspectives of the project are judged to be rather limited.	C
At least three Nordic countries involved	Four Nordic countries have been involved in the project.	B
Potential use of results and information	The potential end-users of the project results are the Nordic emergency management authorities, especially those in Norway having the highest risk of being affected by accidents at Russian nuclear powered vessels.	C
Project results of adequate quality	The quality of the project results is judged to be fairly good.	C
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support has been 150,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 300,000 DKK. The cost-effectiveness is judged to be at the right level.	B
Relevance for authorities and others	The result of the project is relevant for both authorities and others engaged in the assessment of the threats of nuclear facilities to the Nordic countries.	B

Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B–**

2.4.7 EMARAD

The EMARAD project was started in 2002 and will be finalised in the beginning of 2006. The project consists of two major parts, namely pre-calculated consequences of accidents at nuclear power plants located in or close the Nordic countries *and* monitoring strategies that are needed in the management of different nuclear and radiological radiological emergencies.

Objectives

The objectives of the EMARAD project were:

- to establish a web site containing various radiation-threat and radiation monitoring related data and documents and documents that can be used by all the Nordic countries;
- to analyse various factors that can affect direct measurement and sampling strategies in nuclear and radiological emergencies;
- to contribute to harmonisation of radiation monitoring and emergency management strategies;
- to disseminate relevant information on urban dispersion following illicit and malicious use of radioactive materials;
- to extend the network between Nordic experts on consequence analyses, radiation monitoring and emergency preparedness.

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**EMARAD**
NKS-funding:	400,000 DKK (2002), 360,000 DKK (2003), 280,000 DKK (2004), 100,000 DK (2005)
Co-ordinator:	Juhani Lahtinen, STUK (FI)
Participants:	STUK (FI), VTT (FI), NRPA (N), SSI (S), Lund University (S), Geislavarnir Ríkisins (IS), Risø (DK)
Evaluation materials:	Project proposals, Project contract, Project and work descriptions, Working documents and presentations, Draft final report, Summary Report
Published deliverables:	A STUK-hosted web site http://valhalla.stuk.fi containing the following project data and reports: - downloadable nuclear power plant accident consequence for ten power plants located in or close to the Nordic countries - special application programs for processing the accident consequence data - downloadable demos, working documents/reports, presentations on an urban dispersion model and aspects related to malicious use of radioactive materials - draft final project report - NKS-137: Emergency Management and Radiation Monitoring in Nuclear and Radiological Accidents. Summary Report on the NKS Project EMARAD, April 2006, 20 pp. - NKS-142: Emergency Monitoring Strategy and Radiation Measurements. Working Document of the NKS Project Emergency Management and Radiation Monitoring in Nuclear and Radiological Accidents (EMARAD), April 2006, 35 pp.
Missing deliverables:	Proceedings of the NKS-mini-seminar on malicious use of radioactive material

The management of nuclear or radiological emergencies requires pre-planning and that the authorities and their advisers have relevant background material at their disposal. The web based library with the results produced by the EMARAD project are very useful and highly relevant as background material in emergency situations. Of special importance are the application programs for processing the pre-calculated nuclear accident-scenario consequence data.

Possible malicious use of radioactive materials and its consequences has been discussed at a EMARAD mini-seminar. Within this context special concern has been given to urban areas and the use of radiological dispersion devices or so-called 'dirty bombs'. The work on this topic within the EMARAD project has concentrated on the testing of an Urban Dispersion Model (UDM) developed in the UK. Data for calculating the consequences of dispersion of radioactive materials and other pollutants in urban environments are included in the material on the web site.

The problem of defining an emergency monitoring strategy is complicated and requires a systematic approach. The EMARAD project gives a thorough documentation of different monitoring systems and their characteristics and also how environmental factors will affect the measurements. Attention is given to representativeness and interpretation of monitoring data also in relation to the source terms for different types of accident scenarios.

The web site contains a lot of useful material for assessing the consequences of nuclear or radiological accidents in which radioactive materials are released to the atmosphere. It should be considered if some of the material could be copied and transferred to the NKS-B projects URBHAND and Knowledgebase.

Fulfilment of NKS-criteria

The measurable results of the EMARAD project during the period 2002 - 2005 are:

- Project contract and project proposals of 2002, 2004 and 2005
- Project description of 2002, work description of 2004, status reports of 2004 and 2005
- Mini-seminar on Malicious Use of Radioactive material, Stockholm, Sweden, 24 - 25 May, 2005
- Working documents and reports:
  - Emergency monitoring strategy and radiation measurements (2006)
  - Simulation of dispersion in combination of flat, complex and urban terrain (2004)
  - Realistic Urban Scenarios for Copenhagen (2004)
  - Simulation of dispersion in urban areas: Experience gained during the EMARAD work 2002 - 2005 (2005)
  - The implication of airborne contamination created an action of terror in an urban environment (2004)
  - On factors influencing doses from deposition on humans of contaminants dispersed by 'dirty bombs' (2005)
- Published papers in scientific journals:
  - Radiation monitoring strategy: Factors to be considered. Radiation Protection Dosimetry 109 (2004) 1 - 2, pp. 79 - 82

- Effective use of radiation monitoring data and dispersion calculations in an emergency. Accepted for publication in a special issue of the International Journal Risk Assessment and Management 2006

- Draft Final Report Emergency Management and Radiation Monitoring in Nuclear in Nuclear and Radiological Accidents, February 2006
- NKS-137: Emergency Management and Radiation Monitoring in Nuclear and Radiological Accidents, April 2006
- NKS-142: Emergency Monitoring Strategy and Radiation Measurements. Working Document of the NKS Project Emergency Management and Radiation Monitoring in Nuclear and Radiological Accidents (EMARAD), April 2006
- The EMARAD web site at STUK

The project results have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, EMARAD**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework within which consequence analyses of nuclear accidents and development of optimum sampling and measurement strategies are identified areas.	B
Nordic competence and network building and maintenance	The project has contributed to extend the network between Nordic experts on consequence analyses, radiation monitoring and emergency preparedness.	A
The scientific and pedagogical merits of the project	There are several scientific merits of the project, e.g. the development of programs for the processing of nuclear accident consequence data and aspects related to malicious use of radioactive materials. The pedagogical merit of the project is the established web site with various data that can be used in all the Nordic countries.	A
The application and scientific perspectives of the project	The results of the project are applicable at the operational level in case of accidental releases from nuclear power plants and other atmospheric releases of radioactive materials. There are various scientific perspectives of the project, i.e. a further development of the urban dispersion model and the methodology of special application programs to process the accident consequence data.	B
At least three Nordic countries involved	Five Nordic countries have been involved in the project.	A
Potential use of results and information	The potential end-users of the network are the Nordic emergency management authorities. The project results will give users and decision-makers practical tools for assessing the consequences of a wide spectrum of nuclear and radiological accidents.	A
Project results of adequate quality	The quality of the project results is judged to be good.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support in the period 2002 - 2005 has been 1,140,000 DKK. Consequently, the results of the project should be judged against a total manpower effort of 2,280,000 DKK. The cost-effectiveness appears to be at the right level.	B
Relevance for authorities and others	The result of the project is relevant for both authorities and others engaged in the assessment of the threats of nuclear facilities to the Nordic countries and the consequences of nuclear or radiological accidents. Of special importance is the emphasis on the systematic approach of defining a proper monitoring strategy.	A

Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**A–**

2.4.8 IRADES

The project IRADES has been performed in the period 2004 - 2005. The aim of the project was to improve the Nordic emergency preparedness, especially on thyroid measurements following a nuclear or radiological accident. Although an efficient network of Nordic specialists on assessing internal doses has been created in recent years, there is still a need for improving the information on the availability of instruments and the number of trained persons to perform emergency thyroid measurements.

Objectives

The objectives of the IRADES-project were:

- to improve the preparedness for thyroid measurements on people in the early phase of a nuclear or radiological accident
- to assess the inventory of available instruments for thyroid monitoring and to continue the work on inter-calibration and -comparisons on direct measurements of ^{131}I in the thyroid
- to arrange a workshop on inter-comparison and internal dose assessments

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**IRADES - Assessment of Internal Doses in Emergency Situations**
NKS-funding:	50,000 DKK (2004), 50,000 DKK (2005)
Co-ordinator:	Tua Rahola (STUK)
Participants:	STUK (FI), SSI (S), NRPA (N)
Evaluation materials:	IRADES report 2004 for the NKS Board meeting 9 November 2004
Published deliverables:	Project presentation at a NKS-B mini-seminar at Risø 18 - 20 August 2004 NKS-128: Assessment of Internal Doses in Emergency Situations, April 2006, 47 pp. IRADES internal dosimetry course, Tartu, Estonia, Wednesday 26 October 2005 Portable thyroid monitors for detection of ^{131}I in emergency situations, IRADES Paper presented at NSFS meeting in Rättvik 28 - 31 August 2005 Intercomparison exercise for whole-body measurements in the Nordic countries, Draft Report of 13 February 2006
Missing deliverables:	None

In a nuclear emergency situation thyroid measurements are important, both for control of the contamination situation and for later dose assessments. There are different types of measurement systems that can be used for such measurements, *e.g*. thyroid monitors, instruments for uptake measurements of ^{131}I at hospitals, handheld instruments, whole-body counting systems and gamma cameras.

In the report of the former NKS project BOK-2.1.2 an overview of tested instruments for thyroid monitoring was given, but no information on the availability of the instruments was collected. In the project IRADES an inventory of available instruments for thyroid monitoring has been worked out and measurement strategies have been developed. In addition, an inter-comparison exercise for whole-body measurements has also been performed. The phantom IRINA has been circulated

between 13 laboratories in Norway, Sweden and Finland during 2004 and 2005. The results of the inter-comparison show that the participating laboratories in general have well functioning and well-calibrated equipment for whole body measurements.

The results achieved in IRADES-project show that there is a very good network of Nordic 'internal-dosimetry experts' and that this network can be used in an emergency situation should one or all Nordic countries be affected by a nuclear accident. However, there are still important issues in the handling of an emergency situation in practice that need to be addressed, *e.g*. Nordic emergency preparedness exercises on training in simple direct thyroid measurements of people in the early phase of an emergency. The manual produced in the BOK-2.1.2 project could be extended by including data on how many instruments there are available in the Nordic countries in an emergency situation as well as instructions on the use of handheld instruments for thyroid measurements.

Fulfilment of NKS-criteria

The measurable results of the IRADES-project during the project period 2004 - 2005 are:

- NKS-B mini-seminar at Risø in August 2004
- NKS-128: Assessment of Internal Doses in Emergency Situations
- IRADES-Paper 2005: Portable thyroid monitors for detection of ^{131}I in emergency situations, Presentation at the NSFS meeting in Rättvik
- Draft Report 2006: *Intercomparison exercise for whole-body measurements in the Nordic countries*

The results of the IRADES-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, IRADES**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which exercises, measurement strategies and methods are identified project areas.	B
Nordic competence and network building and maintenance	The project has contributed to build new competences on the assessment of internal doses, especially thyroid doses from intake of ^{131}I. A good network of Nordic specialists has been created.	A
The scientific and pedagogical merits of the project	The scientific merit of the project is limited to a status of the capability of the Nordic laboratories to assess internal doses. The pedagogical merit of the project is the identified need for Nordic emergency preparedness exercises on the training in simple direct thyroid measurements in the early phase of an accident.	B
The application and scientific perspectives of the project	The project results are oriented towards the practical application in nuclear emergency situations. The scientific perspectives of the project appear to be limited.	C
At least three Nordic countries involved	Three Nordic countries have been involved in the project.	B
Potential use of results and information	The project results and information have a high potential to be used by professionals performing internal dose assessments in emergency situations.	A
Project results of adequate quality	The quality of the project results is judged to be good.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 100,000 DKK. Consequently, the results of should be judged against a	A

	total manpower effort of 200,000 DKK. The cost-effectiveness appears to be high, i.e. the project costs are low compared to the results of the project.	
Relevance for authorities and others	The result of the project is relevant for both authorities and others engaged in assessment of internal doses following a radiological or nuclear accident.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B+**	

2.4.9 CommTech

The project CommTech has been performed in the period 2003 - 2005. The aim of the project was to bring together at NKS-B mini-seminars key users from the Nordic nuclear and radiological emergency response authorities and experts in different fields of communication technology to exchange views and to encourage a dialogue that would make it easier for the authorities to co-operate and to use modern communication- and IT-technology more effectively in an emergency situation.

Objectives

The objectives of the CommTech-project were:

- to arrange NKS-B mini-seminars on the use of modern IT- and communication technology in emergency situations with participants from Nordic authorities and from relevant international organisations
- to strengthen the dialogue on use of communication technology for emergency preparedness between the Nordic authorities
- to build up and sustain Nordic competence on the use of communication technology in emergency situations

Summary of evaluation

The deliverables and funding of the project are summarised in the table below.

Title:	**CommTech - Communication technology and emergency preparedness**
NKS-funding:	180,000 DKK (2002)
Co-ordinator:	Sigurður Emil Pálsson (Geislavarnir Ríkisins)
Participants:	Geislavarnir ríkisins (IS), STUK (FI), NRPA (N), SSI (S), SKI (S), SIS (DK), DEMA (DK)
Evaluation materials:	Project proposal, seminar presentations
Published deliverables:	NKS-B CommTech mini-seminar at STUK 27 - 28 February 2003 NKS-B CommTech mini-seminar at SSI, Stockholm, 31 May - 1 June 2005 PowerPoint presentations from the mini-seminars
Missing deliverables:	None

Results from the previous NKS work in BOK-1.6/MINEP have been taken into consideration in the CommTech-project. The project has resulted in an active exchange of ideas and experiences between the Nordic authorities and the authorities have also taken an active role in international work on the utilization of communication technology, *e.g.* within the IAEA.

Fulfilment of NKS-criteria

The measurable results of the CommTech-project during the project period 2003 - 2005 are:

- NKS-B mini-seminar at STUK, Helsinki, 27 - 28 February 2003
- NKS-B mini-seminar at SSI, Stockholm, 31 May - 1 June 2005
- PowerPoint presentations from the two mini-seminars
- Poster presentation at the international symposium *Off-site Nuclear Emergency Management - Capabilities and Challenges* held in Salzburg, Austria, 29 September - 3 October 2003

The results of the CommTech-project have been evaluated against NKS-criteria and the results are presented in the table below.

NKS evaluation criteria	**Fulfilment of NKS-criteria, CommTech**	**Grade**
Project falls within NKS-B framework	The project falls within the NKS-B framework in which further development of Nordic collaboration on information in emergency situations is an identified project areas.	B
Nordic competence and network building and maintenance	The project has contributed to build up the competences and strengthened the dialogue on the use of modern communication- and IT-technology in emergency situations	B
The scientific and pedagogical merits of the project	The scientific merit of the project appears to be low. The pedagogical merit of the project has been the mini-seminars for experts in the field and participants from Nordic authorities and international organisations.	B
The application and scientific perspectives of the project	The project results are oriented towards the practical application in nuclear emergency situations. The scientific perspectives of the project appear to be limited.	C
At least three Nordic countries involved	Five Nordic countries have been involved in the project.	A
Potential use of results and information	The end-users of the project results are the Nordic emergency management authorities. The project results have the potential to be used in emergency situations. It is judged that more work would be needed with the aim of harmonisation and standardisation.	B
Project results of adequate quality	The quality of the project results is judged to be good.	B
Project in accordance with plans and budget	The project is in accordance with plans and budget.	B
Cost-effectiveness of total budget	The NKS financial support of the project has been 180,000 DKK. Consequently, the results of should be judged against a total manpower effort of 360,000 DKK. The cost-effectiveness appears to be at the right level for the arrangement of two mini-seminars.	B
Relevance for authorities and others	The result of the project is highly relevant for the Nordic authorities engaged in emergency preparedness and response.	B
Evaluation grade A (very good), B (good), C (average), D (poor), E (very poor)	**B**	

2.4.10 General evaluation of emergency preparedness projects

The emergency preparedness projects have been evaluated against how well they fulfil the aims stated in the project proposals and also against their scientific merits. The following emergency preparedness issues have been included in the different emergency preparedness projects:

- assessment of nuclear or radiological accident consequences in urban areas (Urbhand, UrbContSem)
- assessment of consequences of nuclear accidents at nuclear powered vessels (NucVess)
- emergency measurements of internal doses to thyroid (Irades)
- database on nuclear threats in the Nordic countries (Knowledgebase)
- Nordic network on meteorological services (MetNet)
- communication technology in emergency situations (ComTech)
- probabilistic risk assessment of long-range dispersion and deposition of radionulides from nuclear accidents (NordRisk)
- assessment of the consequences of nuclear or radiological accidents and harmonisation of monitoring and sampling strategies (EmaRad)

The quality of the deliverables varies considerably. Also, the cost-effectiveness, *i.e*. the "return of the investment" in the different projects varies as do the scientific perspectives of the projects. However, many of the projects have the potential of being further developed within Nordic research programmes.

The projects have been evaluated against ten criteria each of which have been given a grade (score) ranging from "very good" to "very poor" (A to E). No individual weighting has been given to these criteria and the final grade of each project is therefore a 'best judgement'. A crude averaging of the "overall quality" of the projects has been performed by adding the number of the same grade over all the projects. The result of this averaging is shown in figure 20.

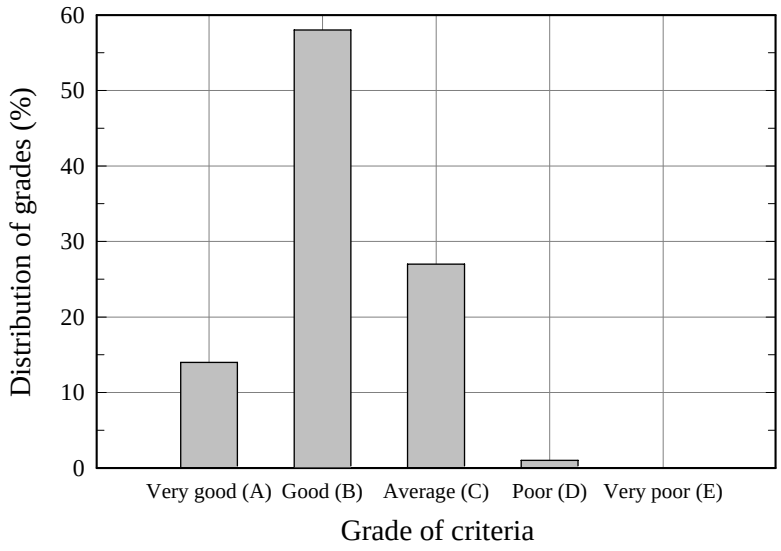


Figure 20. Distribution of grades for ten evaluation criteria over the nine emergency preparedness projects.

The results indicate that the "average overall quality" of the nine emergency preparedness projects in general is quite good as more than 70% of all scores fall within the categories "very good" and "good". Despite the fairly good average score, larger individual differences in 'quality' exist.

To have an indication for the alleged differences in 'quality' between the emergency preparedness projects, the sum of grades of the same category (*A*, *B*, *C* etc.) over the ten evaluation criteria has for each project been weighted using an exponential weighting algorithm:

$$\overline{G} = 2^4 \sum A + 2^3 \sum B + 2^2 \sum C + 2^1 \sum D + 2^0 \sum E$$

where, *e.g.* $\sum A$ is the total number of grade *A* scored for that project.

The relative distribution of NKS-budget on the nine emergency preparedness projects as well as the weighted sum of evaluation grades, $\overline{G}$, for each of the emergency preparedness projects is shown in figure 21.

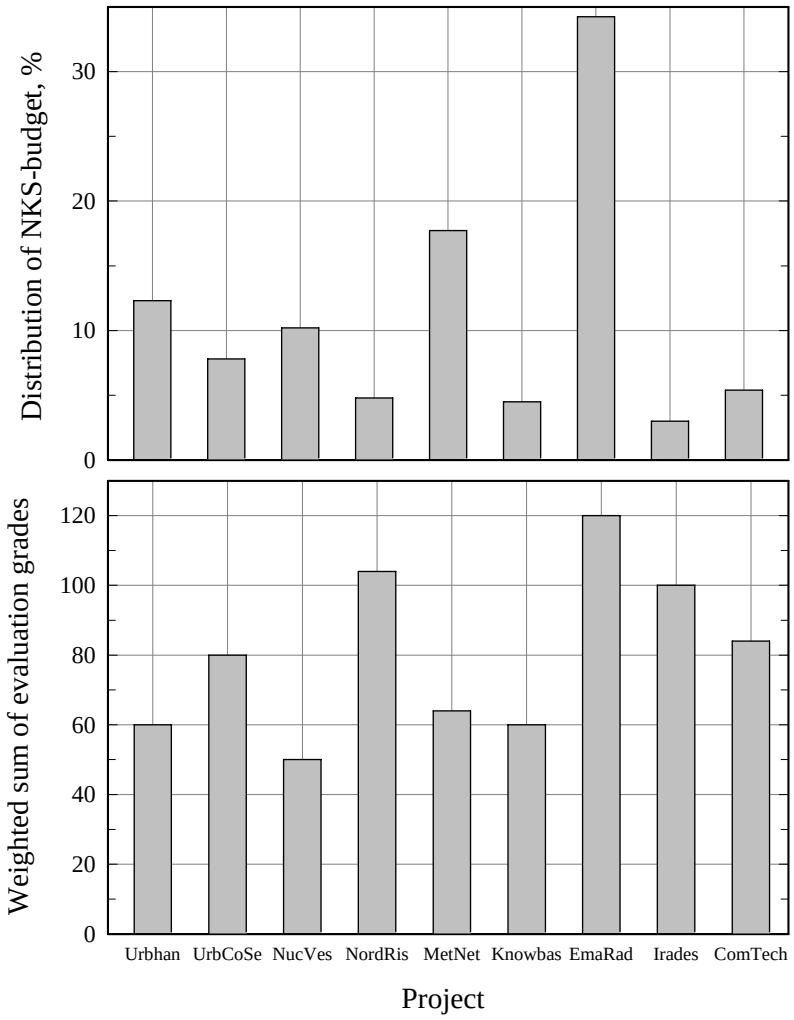


Figure 21. Relative distribution of the NKS-budget and weighted sum of grades for each of the nine emergency preparedness projects.

The total NKS-budget for the emergency preparedness projects is 3,330 kDKK. The largest project is EMARAD, requiring more than a third of the funding for the emergency preparedness projects. It appears to be the "battleship" among the projects, and also the one with the highest weighted grade as shown in figure 21. Another observation is that the project with the second and the third highest weighted grade (NordRisk and IRADES) each has required less than 5% of the total budget.

In the 2002 - 2005 the NKS-B programme the emergency preparedness projects are well-anchored and well-known. In general, all projects are relevant for emergency preparedness and they fulfil the criteria set up in the NKS-B programme. The projects have contributed to (1) maintain and building up competence and to (2) maintain and building Nordic networks between scientists in emergency preparedness disciplines, and these two issues are given the highest priority in the NKS-B programme. The ambition that there should be at least three Nordic countries involved in each accepted activity has also been fulfilled for most of the projects.

Some final reflections from the evaluation of the emergency preparedness projects have been given below:

- It seems from the published deliverables that transverse collaboration between closely related projects have been rather low. In the process of integrating the results of the projects into databases, operational handbooks and decision support systems this kinship between, *e.g*. the projects UrbHand, NucVess, Knowledgebase and EmaRad should be borne in mind.
- The emergency databases and handbooks prepared within the NKS-B programme need updating to be continuously valuable. It seems unclear if such updating has been taken into consideration when the database/handbook-type of projects was launched.
- Relevant parts of the results in the prepared databases/handbooks could with benefit be integrated into existing decision support systems.
- Research-oriented emergency preparedness projects appear to be in the minority on the expense of projects on databases, handbooks, web-sites and seminars. It might be a correct balance, also in the light of the high priority given by NKS to network building, but maintaining and building up competences also needs research projects.

In the preparation of future NKS activities careful consideration - still assuming a high priority on network building - should be given to the balance between research-oriented and more practical-/routine-oriented projects.

2.5 Recommendations and conclusions

The projects in the NKS-B programme for the period 2002 - 2005 have been evaluated against some of the general criteria for evaluating proposals as described in the document NKS(02)6 *Programme handbook 2002 - 2004* as well as the supplementary criteria described in the document *Emergency Preparedness (B) part of the NKS programme 2002 - 2005, NKS-B Framework, Version 2.1*. The present evaluation is based on guidelines dated December 7th, 2005, set out by the NKS Board (see Appendix). For the evaluation, the above-mentioned guidelines were interpreted into ten different criteria, firstly some that judge how well the projects fulfil the aims of the programme, secondly criteria that judge the scientific and pedagogical merits of the project as well as their usefulness and relevance for authorities and end-users. The evaluation included 25 NKS-B projects within three basic fields, *Measurement Strategy, Technology and Quality Assurance* (nine projects), *Radioecological Studies* (seven projects) and *Emergency Preparedness* (nine projects). The total funding, including national in kind funding from the participating institutions, was 20 million DKK, fairly equally distributed between the Nordic countries.

Each of the ten evaluation criteria has been given a grade (score) ranging from “very good” to “very poor” (A to E). In general, the average ‘overall quality’ of the projects has been judged to be quite good in terms of the distribution of grades across all projects as about 70% of all grades were

‘good’ or ‘very good’. However, both ‘quality’ and cost-effectiveness, *i.e*. the ‘return of the investment’, of the different projects vary quite substantially. Also the scientific perspectives of the projects vary. Many of the projects have the potential of being further developed within future Nordic research programmes. The evaluation process has resulted in a number of recommendations and conclusions, which are reported below.

2.5.1 Conclusions

In general, the NKS-B programme has been rather successful, especially seen in the light of the limited resources for the programme. A little less than half of the projects dealt with radioecology, about a third with emergency preparedness and the remaining with measurement technology. The net NKS-funding of the NKS-B programme was 10 million DKK for 25 projects (nine measurement technology, seven radioecology and nine emergency preparedness projects) over four years, corresponding to an average annual NKS-support of 100,000 DKK per project, which is equivalent to approximately 1 man·month/year per project. Despite this modest contribution the outcome of the NKS-B programme has been quite good in terms of 11 mini-seminars and 23 reports in the NKS-series. Many of these NKS-reports have a high standard and the seminars have all been very successful.

The nine projects on *Measurement Strategy, Technology and Quality Assurance* were a valuable part of the NKS-B programme, and all fulfil the criteria set up in the NKS-B programme. The projects on field-measurements and laboratory-based analysis were highly relevant, and very valuable results have been obtained from both field exercises and laboratory intercomparisons. Nevertheless, radiological measurements constitute an expertise only mastered by a few institutions in each of the Nordic countries. Future NKS-projects therefore have the opportunity to further develop and maintain this competence as well as to work out common protocols and procedures that will ensure coordinated actions within the Nordic countries in case of an emergency.

The seven *Radioecological* projects all fulfil the criteria set up in the NKS-B programme. Reliable data for prediction of possible doses to humans from different ecosystems, to be used in decision-support systems, has been established. It is, however, not always clear how the results achieved will be utilised in a systematic manner to further strengthen the expertise within the field of radioecology. To improve decision-support systems, critical analyses to identify which data are most needed to strengthen system performance should be made and the data should be acquired through focused project work.

The nine *Emergency Preparedness* projects have been well anchored. In general, all the projects have been relevant for emergency preparedness and they fulfil the criteria set up in the NKS-B programme. The projects have contributed to maintain and building up competence and to maintain and create Nordic networks between scientists in emergency preparedness disciplines. However, transverse collaboration between closely related projects seems to have been rather low but might be improved in future project work on integrating the achieved results into broader decision-support systems. Another reservation is if preparation of databases and handbooks is a natural part of NKS research programmes. If so, updating is necessary for the databases/handbooks not to be useless after some years and it is unclear if this aspect has been considered at the onset of such projects.

In summary, each of the NKS-B projects have been evaluated by ten criteria that emerged from the interpretation of the NKS-guidelines and each of these criteria have been graded by a score ranging from very good to very poor (A to E). These scores have been weighted to obtain an overall

weighted grade for each project. Figure 22 presents the cumulative weighted grades for the NKS-B projects.

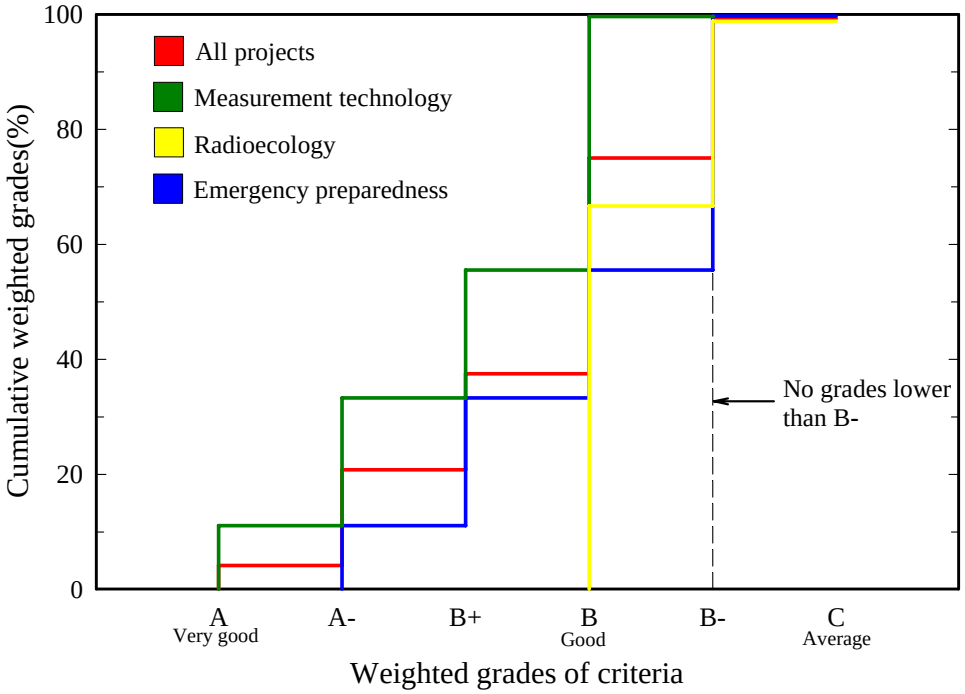


Figure 22. Cumulative weighted grades for each of the three main project groups and for all NKS-B projects as a whole.

Comparing the cumulative weighted grades between the three NKS-B project groups in figure 22, the “Measurement Technology” projects are ranked highest and the “Radioecology” projects lowest. The weighted grades for the “Emergency Preparedness” projects are closer to the average weighted grade for all the NKS-B projects as a whole. In addition, figure 22 shows that the weighted grades for all NKS-B projects are better or equal to B**–.**

In figure 23 the average weighted grade is presented for each of the ten criteria for the three project groups as well as for all the projects as a whole. It appears from figure 23 that for eight of the ten criteria the “Measurement Technology” projects are ranked highest and that for six of the ten criteria the “Radioecology” projects are ranked lowest.

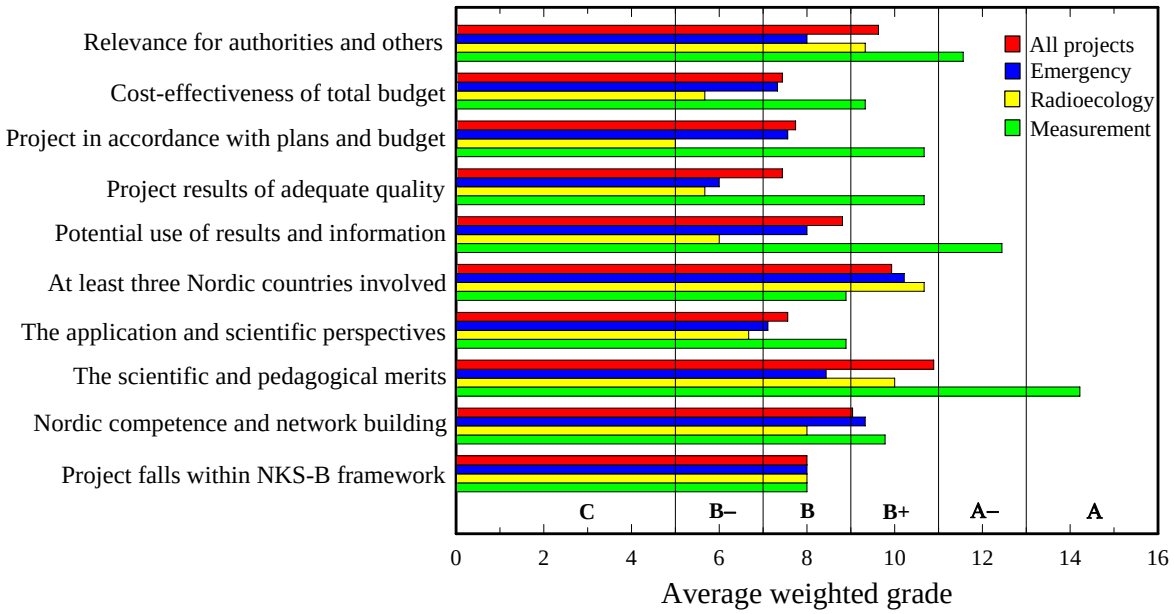


Figure 23. Average weighted grades for each of the ten criteria that emerged from the interpretation of the NKS-guidelines for each of the three main project groups and for all NKS-B projects. The intervals for each of the average weighted grades from C to A are indicated.

2.5.2 Recommendations

In general, the NKS B programme with its three sub-programmes on (1) Measurement strategy, Technology and Quality Assurance, (2) Radio-ecological Studies and (3) Emergency preparedness was judged to be fairly good. However, it is recommended that the future composition of the NKS-B programme should be reconsidered. New sub-programmes like decommissioning of nuclear facilities and radioactive waste treatment – still within the context of radiological protection - might be added or substitute some of the existing sub-programmes.

In future NKS-B projects a balance between research-oriented and more practical-/routine-oriented projects should be considered carefully. Also more clear communication of the project results, integration of project results into decision-support systems, better integration of NKS-activities with relevant EU-activities, and inclusion of university departments in research projects should be further examined.

The scientific seminars and workshops organised within the NKS-B programme were very useful instruments to communicate the results of the projects more widely, to build network between Nordic scientists and attract young scientists, and also to perform courses in different disciplines like internal dosimetry, spectral data processing and sampling strategies. It is highly recommended that this activity should be continued and strengthened in the next framework programme. The seminars might be even more efficient if they were organised transversely between related projects within the programmes but also between the R and B programmes NKS has in the past in the NKS-B programme supported PhD-education of young scientists (e.g. through the projects Rein and NucVess). Considering the limited NKS-funding, such an activity is prohibitively expensive and very little cost-effective. The attraction of young scientists to the nuclear and radiological profession is indeed extremely important and the support to their education is one of the criteria for the NKS activities. It is therefore recommended that NKS for the next framework programme

should consider various possibilities to support university students in the nuclear or radiological field, *e.g*. by financial incentives to offer MSc thesis projects, preferably with a Nordic collaboration element. Projects for graduate students are easier established than PhD projects, require much less financing, and probably represent a good strategy for helping to recruit young research candidates into the field.

The process of evaluating NKS-projects needs a careful re-evaluation. When the four-year programme structure was left and more continuous programmes were introduced, the former evaluation procedure more or less lost its validity. Without a fixed deadline for the final project reports to be evaluated, the evaluation process becomes rather difficult, especially when tying the outcome of the evaluation process to a fixed-date status seminar. It is therefore recommended that the NKS-project reports (final or intermediate) to be evaluated are sent to the evaluators in due time before the status seminar, and that no later-stage project reports should enter the evaluation process. Alternatively, the evaluation process could be a "rolling" process, *i.e*. each project would be evaluated in line with its completion. Such a prolonged evaluation could, however, be considered more inconvenient for the evaluators.

Appendix 1: Direktiv för utvärderingen

Byrån

Nordisk kernesikkerhedsforskning
Norrænar kjarnöryggisrannsóknir
Pohjoismainen ydinturvallisuustutkimus
Nordisk kjernesikkerhetsforskning
Nordisk kärnsäkerhetsforskning
Nordic nuclear safety research

NKS(05)6 Rev 1
2005-12-07

Direktiv för utvärdering av NKS-verksamheten 2002 - 2005

Inledning

Dessa direktiv är antagna av styrelsen vid dess möte i Reykjavík den 17 november 2005

Utvärderingen ska omfatta de två fackliga delarna: R och B. Namnen på utvärderarna framgår av referatet från styrelsemötet. En process för revidering och effektivisering av NKS' struktur, organisation och administration pågår parallellt och berörs inte av denna utvärdering.

Metod

Utvärderarna ska sträva efter största möjliga flexibilitet i sitt arbete och själva fördela arbetsuppgifterna mellan sig. De kan vid behov kalla in andra personer med särskild kompetens som bedöms som värdefull. Exekutivsekreteraren ska kontaktas i startfasen av utvärderingen och hållas löpande informerad om arbetet vad avser status i förhållande till tidsplaner och budget.

Utvärderarna har rätt att från styrelsen (inklusive ägarna och byrån), programcheferna och sekretariatet begära sådan information (elektronisk, skriftlig, muntlig) som krävs för att genomföra utvärderingsarbetet på ett effektivt och nöjaktigt sätt. Vidare har utvärderarna rätt att via intervjuer, deltagande i möten, seminarier etc skaffa sig kompletterande information. För sitt arbete disponerar varje utvärderare DKK 40 000. De tillrättalägger själv sina resor, möten, intervjuer etc. Slutrapporter för R- och B-utvärderingarna på vardera maximalt cirka 30 A4-sidor (inklusive inledning, rekommendationer, sammanfattande värdering och kort redovisning av kostnaderna för utvärderingsarbetet) sänds i elektronisk form till NKS-sekretariatet. Rapporterna kommer att sammanställas till en gemensam NKS-rapport och publiceras i såväl tryckt som elektronisk form. Ett utkast till NKS-rapporten ska presenteras och diskuteras på styrelsemötet i maj 2006 enligt den översiktliga tidsplanen nedan.

Översiktlig tidsplan

17 nov 2005	Styrelsemöte i Reykjavík; start för utvärderingen av verksamheten 2002 – 2005
dec'05 – april'06	Utvärderingsarbete
13 april 2006	Utkast till slutrapporter sänds elektroniskt till NKS-sekretariatet
13 – 26 april 2006	Sekretariatet sammanställer en samlad NKS-rapport som sänds ut till styrelsen
13 april – 10 maj	Kompletterande utvärderingsarbete
10 – 11 maj 2006	Statusseminarium i Otnäs
11 maj 2006	Styrelsemöte i Otnäs med diskussion om NKS-rapporten
maj 2006	Justeringar av NKS-rapporten, som vid behov sänds elektroniskt till styrelsen för godkännande via en snabb "silent procedure"
juni – juli 2006	NKS-rapporten trycks, distribueras och publiceras på hemsidan

Kriterier för NKS-aktiviteter

- Det ska finnas ett påtagligt nordiskt mervärde, inklusive
  - skapande och vidmakthållande av nordiska nätverk
  - spridning och utvidgning av nordisk kompetens inom sakområdet
  - satsning på unga nordiska forskare
- Det teknisk/vetenskapliga innehållet ska hålla hög internationell standard och ha ett nyhetsvärde
- Arbetet ska präglas av en helhetssyn samt vara transparent och öppet för bredast möjliga deltagande
- Det ska gå att ställa upp tydliga och mätbara mål för såväl det teknisk/vetenskapliga arbetet som informations- och kommunikationsinsatser
- Resultaten av verksamheten ska vara av påtaglig nytta för finansiärer och slutanvändare
- Där så är möjligt och lämpligt kan stöd ges till PhD- och MSc-studerande
- De praktiska resultaten ska presenteras i form av
  - seminarier, temamöten etc
  - tekniska rapporter och vetenskapliga artiklar i internationellt erkända publikationer
  - rekommendationer, manualer, handböcker, checklistor
  - CD-ROM, hemsidor och andra elektroniska media
  - undervisnings- och informationsmaterial
- Arbetet ska bedrivas så kostnadseffektivt som möjligt
- När så är lämpligt och möjligt ska NKS-arbetet koordineras internationellt
  - med det arbete som bedrivs av EU, IAEA och OECD/NEA
  - inom ramarna för pågående nordisk samverkan med länder i östra Europa

Utvärderingen av R- och B-delarna

R-delen: Reaktorsäkerhet inklusive avveckling och radioaktivt avfall

B-delen: Beredskap inklusive radioekologi och beredskapsrelaterad information/ kommunikation

Syfte med utvärderingen:

A Fastställa om arbetet varit välplanerat, användbart och kostnadseffektivt

B Undersöka i vad mån NKS-kriterierna (se ovan)
- var relevanta
- uppfyllts

C Dra lärdomar av erfarenheterna och ge rekommendationer inför framtiden

Några frågor som utvärderingen av R- och B-delarna bör försöka besvara:

1. Är NKS-aktiviteterna förankrade och välkända?
2. Har nordisk kunskap och samsyn ökat genom aktiviteterna? Har NKS-arbetet hjälpt till att bevara och utveckla det nordiska kontaktnätet?
3. Har NKS-arbetet hjälpt till att upprätthålla och utveckla expertis? Har möjligheterna till utbildning och engagemang av unga forskare tagits till vara?
4. Saknas några viktiga fackområden i NKS-arbetet? Kan några områden nerprioriteras eller utgå?
5. Är resultaten av aktiviteterna av tillräckligt god kvalitet? Om inte, vad är orsaken?
6. Följdes arbetsplan, tidsplan, budget?
7. Positiva och negativa erfarenheter av NKS-arbetet? Särskilda problem?
8. Lärdomar och rekommendationer inför det fortsatta NKSarbetet?

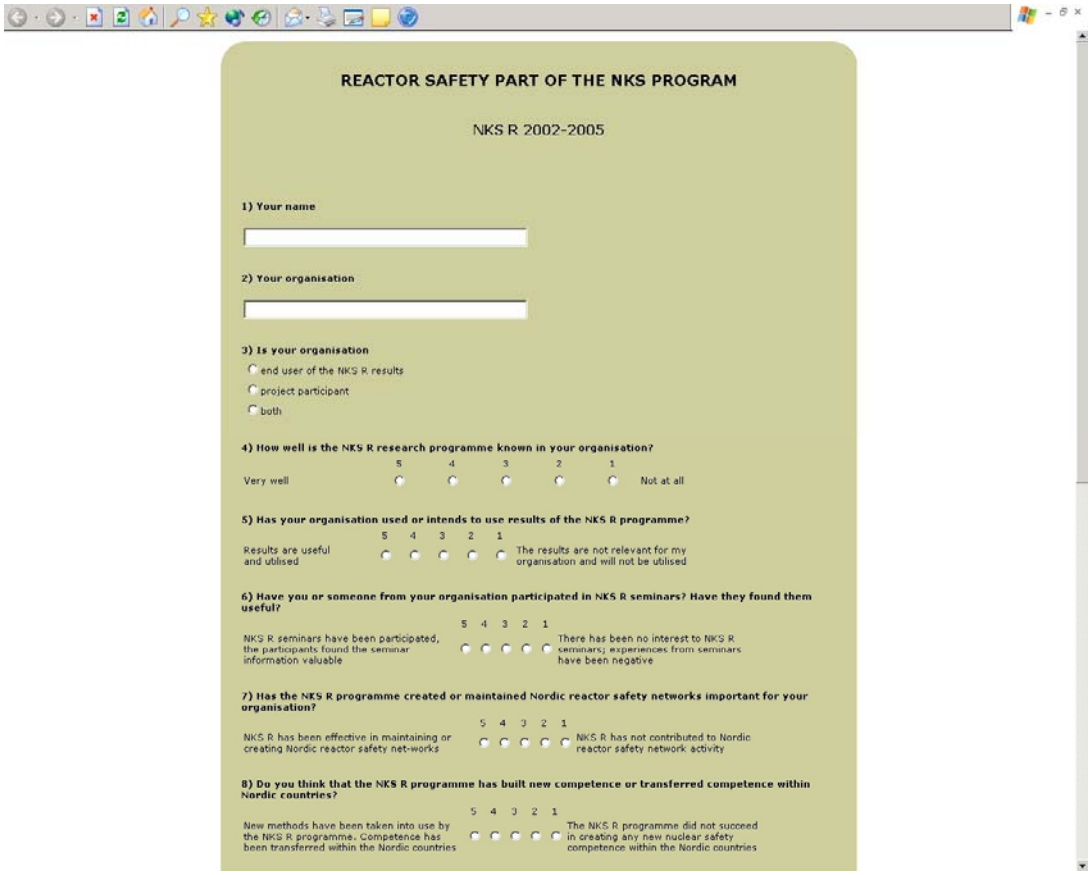
Utvärderarna av R- respektive B-delen avgör själva vilka bedömningsregler och betygsskalor eller liknande som ska användas.

Övrigt

Referensmaterial för utvärderingen av R- och B-delarna:

* Ramverket för R resp B (Framework Program) med bl a programstruktur, forskningsområden, kriterier, aktiviteter och Call for Proposals
* Dokumentation av processen med Call for Proposals under perioden
* Statusrapporter till styrelsen
* Tekniska rapporter, vetenskapliga artiklar och liknande publikationer
* Programhandboken, NKS(04)6 daterad 2004-12-08
* Tidigare utvärderingsrapporter, särskilt NKS-66 från november 2002
* Referat från styrelsemöten
* Kompletterande material på NKS' hemsidor

Appendix 2: NKS-R Questionnaire



REACTOR SAFETY PART OF THE NKS PROGRAM

NKS R 2002-2005

1) Your name

2) Your organisation

3) Is your organisation

- end user of the NKS R results
- project participant
- both

4) How well is the NKS R research programme known in your organisation?

	5	4	3	2	1	
Very well	○	○	○	○	○	Not at all

5) Has your organisation used or intends to use results of the NKS R programme?

	5	4	3	2	1	
Results are useful and utilised	○	○	○	○	○	The results are not relevant for my organisation and will not be utilised

6) Have you or someone from your organisation participated in NKS R seminars? Have they found them useful?

	5	4	3	2	1	
NKS R seminars have been participated, the participants found the seminar information valuable	○	○	○	○	○	There has been no interest to NKS R seminars; experiences from seminars have been negative

7) Has the NKS R programme created or maintained Nordic reactor safety networks important for your organisation?

	5	4	3	2	1	
NKS R has been effective in maintaining or creating Nordic reactor safety net-works	○	○	○	○	○	NKS R has not contributed to Nordic reactor safety network activity

8) Do you think that the NKS R programme has built new competence or transferred competence within Nordic countries?

	5	4	3	2	1	
New methods have been taken into use by the NKS R programme. Competence has been transferred within the Nordic countries	○	○	○	○	○	The NKS R programme did not succeed in creating any new nuclear safety competence within the Nordic countries

9) Has the programme provided possibilities for young scientists?

	5	4	3	2	1	
New research possibilities for young scientists have been created	○	○	○	○	○	The NKS R programme did not create new possibilities for young scientists

10) How do you consider the scientific level of the NKS R programme?

	5	4	3	2	1	
The scientific level has been world class	○	○	○	○	○	The scientific level has been poor

11) How do you consider that balance of the programme? Have important organisations been involved? Have there been enough information spreading activities in form of seminars, etc?

12) What is your opinion of the priorities given for various research fields in the current NKS R programme? Do you think that important activities are missing?

13) What are your recommendations for future work?

14) Do you have any additional comments or recommendations?

Submit

Appendix 3: Acronyms and Abbreviations

AGS	Air-borne Gamma Spectrometry
APRI	Accident Phenomena of Risk Importance (Swedish research program)
ARGOS	Accident Reporting and Guiding Operational System (Denmark)
BWR	Boiling Water Reactor
CCF	Common Cause Failure
CFD	Computational Fluid Dynamics
CGS	Car-borne Gamma Spectrometry
DD	Danish Decommissioning
DELI	Development and Validation of Assessment Methods and New Technology (NKS-R reserarch theme, comprising a number of activities)
DeliPool	Condensation pool experiments (NKS-R activity)
DEMA	Danish Emergency Management Agency
DKK	Danish currency unit (crowns, kroner; also kDDK and MDKK)
DTU	Technical University of Denmark
ECODOSES	Improving radiological assessment of doses to man from terrestrial ecosystems (NKS-B activity)
ECOMAGS	Nordic – EU collaboration on design and evaluation of the RESUME 2002 exercise (NKS-B activity)
EMARAD	Emergency management & radiation monitoring in nuclear and radiological accidents (NKS-B activity)
EU	European Union
FOI	Swedish Defense Research Agency
FRIT	Danish Science Research Councils' Instrument Service
GR	Icelandic Radiation Protection Institute
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IFE	Institute for Energy Technology (Norway)
INDOFERN	New indicator organisms for environmental radioactivity (NKS-B activity)
KTH	Royal Institute of Technology (Sweden)
LOCA	Loss of Coolant Accident
LUT	Lappeenranta University of Technology (Finland)
MainCulture	Maintenance culture and management of change (NKS-R activity)
MANGAN	Management and Organization of Safety and Quality Assurance (NKS-R research theme, comprising a number of activities)
MFM	Multilevel Flow Modelling
MGS	Mobile Gamma Spectrometry
MS	Mass Spectrometry
MU	Mälardalen University
NGU	Geological Survey of Norway
NKS	Nordic Nuclear Safety Research
NKS-B	Emergency Preparedness Program of NKS

NKS-R	Reactor Safety Program of NKS
NLH	Agricultural University of Norway
NORTHNET	Nordic Thermal Hydraulic Network
NPSAG	Nordic PSA Group
NRPA	Norwegian Radiation Protection Authority
NSFS	Nordic Society for Radiation Protection
NTNU	Norwegian University of Science and Technology, Department of Physics
OECD/NEA	Organization for Economic Cooperation and Development/ Nuclear Energy Agency
OKG	Oskarshamns Kraftgrupp (Sweden)
POOLEX	Condensation Pool Experiments (Finnish research activity)
PSA	Probalistic Safety Analysis
PWR	Pressurized Water Reactor
RESUME	Rapid Environmental Surveying Using Mobile Equipment (NKS-B exercises)
SGU	Geological Survey of Sweden
SIS	Danish Radiation Protection Authority
SKI	Swedish Nuclear Power Inspectorate
SLU	Swedish University of Agricultural Sciences
SSI	Swedish Radiation Protection Authority
STUK	Radiation and Nuclear Safety Authority (Finland)
SU	Stockholm University (Sweden)
TACO	Traceability and communication of requirements in digital I&C systems development (NKS-R activity)
TVO	Industrial Power, Ltd. (Finland)
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VALDOR	Values in Decisions on Risk (A series of NKS-supported international conferences)
VTT	Technical Research Center of Finland

Bibliographic Data Sheet **NKS-145**

Title	Evaluation of NKS Research Activities during 2002 - 2005
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Abstract	NKS research work during the years 2002 – 2005 and its results have been evaluated against a set of criteria defined by the NKS Board. The evaluation encompassed the NKS-R (reactor safety) and NKS-B (emergency preparedness) programs and was conducted by two persons per program. The mode of work of the two evaluation teams was adapted to the special conditions of the program at hand, one being aimed more at the nuclear industry and the other at a more academic surrounding; in both cases, however, with great involvement of relevant national authorities. The findings of the evaluators are presented in this report. Financing and participating organizations, end users, deliverables, quality aspects, cost-benefit issues, time schedules, budgets and related issues are discussed. Finally, the sections on NKS-R and NKS-B, respectively, include conclusions and recommendations for future NKS work.
Key words	accidents; ageing; application; automation; call for proposals; competition; contamination; control room; cost calculation; criteria; decision support system; decommissioning; deliverable; dose assessment; emergency preparedness; end user; environment; evaluation; funding; indicator organisms; in-kind contribution; intercomparison; interview; measurement; monitoring; network; Nordic dimension; nuclear safety; objectives; organizational issues; plant lifetime management; probabilistic safety analysis; program manager; protection; quality assurance; questionnaire; radiation; radioactive; radioecology; release; remediation; risk analysis; safety culture; sampling; spectrometry; thermal hydraulics; waste

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