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Werner Burkart, Henri Métivier, John Stather, Terttu Vartiainen

International Evaluation of the Research Activities of Radiation and Nuclear Safety Authority (STUK)

MINISTRY OF SOCIAL AFFAIRS AND HEALTH
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Summary

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The Ministry of Social Affairs and Health invited a multi-professional Panel of international and national experts to evaluate the research activities of the Finnish Radiation and Nuclear Safety Authority - STUK. The evaluation was based on extensive written material and a site visit.

The Evaluation Panel found that in the European level and even in the world scale STUK is among the top research institutions in its field largely due to the multidisciplinary know how and the understanding and insight in the implementation of the research results in order to support the whole organisation's mission. The Evaluation Panel also assessed that STUK's research output with few exceptions is done on relevant research questions, and is in most areas of high or even highest international quality, cost efficient and mainly organised in a proper manner. The Evaluation Panel made several recommendations on management and scientific issues.

Key words: STUK, Radiation and Nuclear Safety Authority, evaluation, radiation, research, management, organization

Tiivistelmä

Werner Burkart, Henri Métivier, John Stather, Terttu Vartiainen. International Evaluation of the Research Activities of the Finnish Radiation and Nuclear Safety Authority (STUK). Helsinki 2001, xxx s. (Sosiaali- ja terveysministeriön selvityksiä, ISSN 1236-2115; 2001:5) ISBN 952-00-0976-0

Sosiaali- ja terveysministeriön kutsusta kansainvälinen, monitieteellinen asiantuntijaryhmä arvioi Säteilyturvakeskuksen (STUK) tutkimustoiminnan. Asiantuntijaryhmässä oli myös edustaja Suomesta. Arviointiryhmä tutustui STUKin tutkimustoimintaan vierailemalla STUKissa ja perehtymällä ryhmälle ennakkoon toimitettuun runsaaseen kirjalliseen materiaaliin. Arviointiryhmä totesi, että STUK kuuluu alallaan Euroopan ja jopa koko maailman johtaviin tutkimuslaitoksiin, kun otetaan huomioon STUKin monitieteellinen asiantuntemus ja tutkimustulosten hyödynnettävyys STUKin muilla tulosalueilla. Asiantuntijaryhmä arvioi, että pääosin STUKin tutkimus on kohdistunut alan keskeisiin tutkimusongelmiin ja että useimmilla aloilla se on laadultaan korkeatasoista. Arviointiryhmä teki runsaasti sekä tutkimusten johtamiseen että tieteellisiin kysymyksiin liittyviä suosituksia.

Asiasanat: STUK, Säteilyturvakeskus, arviointi, säteily, tutkimus, johtaminen, organisaatio

Sammandrag

Werner Burkart, Henri Métivier, John Stather, Terttu Vartiainen. International Evaluation of the Research Activities of the Finnish Radiation and Nuclear Safety Authority (STUK). Helsingfors 2001, xxx s. (Social- och hälsovårdsministeriets rapporter, ISSN 1236-2115; 2001:5)
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På inbjudan av social- och hälsovårdsministeriet bedömde en internationell, tvärvetenskaplig expertgrupp forskningsverksamheten vid Strålsäkerhetscentralen. I gruppen ingick också en finländare. Gruppen bekantade sig med Strålsäkerhetscentralens forskning på platsen och genom att studera rikligt med skriftligt material. Expertgruppen konstaterar, att Strålsäkerhetscentralen hör till de ledande forskningsinstituten på sitt område både i Europa och i hela världen, när man beaktar Strålsäkerhetscentralens tvärvetenskapliga sakkunskap och hur forskningsresultaten kan utnyttjas på många områden inom Strålsäkerhetscentralen. Expertgruppen bedömer, att Strålsäkerhetscentralens forskning i huvudsak ägnat sig åt centrala forskningsproblem och på de flesta områden varit av hög klass. Expertgruppen överlämnade många rekommendationer som gäller hur forskningsarbetet skall ledas samt vetenskapliga frågor.

Nyckelord: STUK, Strålsäkerhetscentralen, evaluering, strålning, forskning, ledning, organisation

Preface

The Ministry of Social Affairs and Health and Radiation and Nuclear Safety Authority (STUK) agreed in 1999 that the scientific output of STUK will be evaluated by an international expert Panel in the year 2000. The evaluation of STUK's research activities was the last of four consecutive international reviews of institutes under the Ministry of Social Affairs and Health. National Public Health Institute (KTL) and Finnish Institute of Occupational Health (TTL) were evaluated in 1995 and National Research and Development Center for Welfare and Health (STAKES) in 1999. All these evaluations were based on a decision made by the Council of State for Science and Technology. The decision required that all governmental organisations dealing with research be subjected to an external evaluation.

The Ministry of Social Affairs and Health invited a multi-professional Panel of international and national experts for the evaluation of STUK's research activities. The Panel was chaired by Professor Werner Burkart (German Federal Office for Radiation Protection, moving to the International Atomic Energy Agency during the evaluation). The other members appointed to the Panel were Professor Henri Métivier (Institute for Nuclear Safety, France), Doctor John Stather (National Radiological Protection Board, United Kingdom) and Professor Terttu Vartiainen (Academy of Finland, Finland).

The present Evaluation Panel review covered strategy, organisation, and results of radiation protection research. The aim of the Panel was not to carry out in-depth analysis of programs but instead to give some general recommendations for developing further STUK’s research activities. The Evaluation Panel has put great emphasis on national and international context and potential for sharing of responsibilities to secure Finland’s needs for radiological protection which is the ultimate mission of STUK.

The Ministry of Social Affairs and Health was pleased to note that the Panel found that in the European level and even in the world scale STUK is among the top research institutions in its field largely due to the multidisciplinary know how and the understanding and insight into the implementation of the research results in order to support the whole organisation’s mission. This is good news because of STUK’s vision to become included in the European Centres of Excellence in the field of radiation protection research. However, before STUK gains this status and earns fully its potential leading role in the Nordic/Baltic area an increased number of joint research projects and foreign researchers working in STUK are needed.

The Panel has several recommendations, which should steer STUK’s research activities so that an excellence status could be obtained. Apparently even more high quality peer reviewed research is desirable, some current research should be re-directed, reviewed and even discontinued after review. As many research disciplines covered by STUK represent small and highly specialised scientific areas, this - at least in part – explains the fact that STUK’s research is relatively seldom published in the journals having highest citation impact. Thus, it is evident that the excellence of STUK's research output cannot be measured by only looking at published reports' citation impact, as the Panel admits itself. In many occasions - such as in research related to emergency preparedness - quality and relevance can or even must be measured by other means.

In summary, based on the Panel's analysis, it appears that STUK's research output with few exceptions is done on relevant research questions, and is in most areas of high or even highest international quality, cost efficient and mainly organised in a proper manner.

Panel urges the Ministry of Social Affairs and Health to regularly review and even redefine STUK's research policies so that strategic needs that are somewhat changing with time are met. Panel also urges ministry to steer research policies in the area of public health so that a more holistic approach to the either man made or natural genotoxic environment could be accomplished, i.e. panel wishes a deepened co-operation between all health research institutions in Finland. An important issue which has direct links with governmental steering was the panel's concern that most public sector research institutions are heading towards an increase in limited time contracts at the expense of tenure positions at the same time when many senior scientists are about to retire. This, potentially threatens the continuity of STUK's research activities. It must be emphasised, however, that STUK is not alone facing this difficult question.

The Ministry of Social Affairs and Health was pleased to note that STUK's efforts to inform the public on radiation protection issues is highly regarded. These efforts are essential in order to manage the challenging task of proper risk communication with the public so that misunderstanding, and at worst fear or even panic can be avoided and/or managed as much as possible.

STUK is a regulatory body as well as a research institute. The main functions of STUK have now been evaluated by international evaluators, as STUK's regulatory functions were reviewed in the beginning of the year 2000.

Finally, I would like warmly to thank the Evaluation Panel of its efforts and constructive proposals to support the work of STUK. The results of this evaluation and the conclusions to be drawn from it for the further development of the research conducted by STUK will be a matter of discussions between the Ministry of Social Affairs and Health and STUK and will also be discussed by the Board of Directors of STUK. The actions to be taken on the basis of the evaluation will be a challenge for the years to come.

Jarkko Eskola
Director General
Department for Promotion and Prevention
Ministry of Social Affairs and Health

Members of the Evaluation Panel

Professor Dr. Werner Burkart, Chairman of the Evaluation Panel, is Deputy Director General of the IAEA (International Atomic Energy Agency) and heads the Department of Nuclear Sciences and Applications with its laboratories in Seibersdorf, Monaco and Vienna. He is responsible for the non-power nuclear applications in the area of food and agriculture, human health, marine and terrestrial environment, and physical and chemical sciences.

After studying Biochemistry and Microbiology at the Swiss Federal Institute of Technology in Zurich where he obtained his Masters Degree and Ph.D. in Biochemistry, he received a M.S. in Environmental Health after studying radiological health, epidemiology and actinide metabolism in primates at the Institute of Environmental Medicine of the New York University Medical Centre.

His professional assignments started with work at the Swiss National Science Foundation in Berne as Head of the Biology and Medicine Division from 1973 to 1975. Then, he joined the Swiss Institute for Reactor Research at Würenlingen where he held different research and development assignments in radiation biology, radioecology and radiation protection. After research work in developmental neurobiology and cell-cell interaction in organ formation at the Biocenter of the Basel University and the Marine Biological Laboratory at Woods Hole, USA, he was from 1982 to 1987 the Assistant Head of the Health Physics Division and Head of the Biology and Environment Group of the Swiss Institute for Reactor Research at Würenlingen. From 1988 to 1990 he became Head of the Radiation Hygiene Division of the Paul Scherrer Institute in Villigen, Switzerland. In 1991 Prof. Burkart joined the German Federal Office for Radiation Protection. From then onwards he held the position of Head of the Department of Radiation Hygiene at its Munich and Freiburg institutes. In addition he is Professor for Radiation Biology at the Faculty of Medicine of the Ludwig Maximilians University in Munich.

His more recent professional activities and publications have been mainly concerned with integral risk assessment; dose / effect relationships from low-level exposures to radiation and chemicals (combined effects); radiation biology of the lung (radon), Validation of environmental and health data in relation to major contaminations.

His consultation and advisory work include serving as member: of the Swiss Federal Reactor Safety Commission from 1983 to 1995 (Chairman of the Chapter Waste Disposal and Radiation Protection), of the group Radioécologie Nord-Contentin, Paris (1998 - 2000), of the Scientific Council ANDRA, Paris (1999 onwards), and of the Project Advisory Committee for the Research Reactor Garching II, München. He also contributed to UNSCEAR (Consultant for "*Combined effects of radiation and other agents"*); to Worker's compensation boards, to OECD/NEA (Working group on "*Scientific input for the development of radiation protection"*), to WHO (Chairman for the Review of the *"Int. Thyroid Project"*), and to the Euratom Coordination Committee and to research review panels of the European Union. He serves on the Editorial Boards of "*Radiation and Environmental Biophysics"*, Springer (publisher), Heidelberg, and "*The Science of the Total Environment"*, Elsevier (publisher), Amsterdam.

Professor, PhD Henri Métivier is Director of Research of the Nuclear Protection and Safety Institute (IPSN) in Fontenay aux Roses, assistant of the director for protection of man and environment, Professor of radiation protection at the National Institute for Nuclear Sciences and technology (INSTN) in Saclay.

After obtaining his first degrees (master of sciences) in the chemical sciences at Paris University (La Sorbonne), he obtained a speciality in radiochemistry in Curie Institute, then a PhD at the University of Paris in radiochemistry. He joined the Atomic Energy Commissariat, military branch, in 1972, he became deputy head of Experimental toxicology and in 1982, head of toxicology and cancerology unit of the IPSN. In 1989 he joined the director of nuclear safety research of the IPSN, then became in 1995 Director of research and took the responsibilities of IPSN- University relationships and the responsibility of fellows doing PhD. In 1999 he was nominated Professor at INSTN.

His research work has been mainly concerned with actinides, speciation of plutonium at low levels for human extrapolation, biochemistry linked to the effects of plutonium in lungs, and connective tissues pathologies of the lung linked to radiation or not, biokinetic (after inhalation and ingestion) and carcinogenesis of actinides compounds. He has also been responsible for the creation of protection rule of workers experimenting with HIV viruses in animals, more especially in monkeys.

He has published, 212 publications, 51 as first author in international journals, 36 as first author in French journals, 90 as co-author in international journals and, 35 in French journals

He has acted as a consultant of ICRP in different task groups. He is member of ICRP Committee 2 and chairman of human ICRP Alimentary Tract Task Group. He was a member of a scientific Advisory Group to the CEC Radiation program to the CEC on the radiation protection program. He is evaluator of CEC INTAS program, and has in charge for the CEC to establish a European competence map for radiological sciences researches. He is vice chairman of the OECD/NEA CRPPH (Committee for radiological protection and public health) He is chairman of scientific committee of the Department of radiation measurements of units of the CEA.

He has participated to organisation of several international symposia and he is the director of a scientific collection (13 volumes to day, 3 to be published) devoted to nuclear protection and safety. He is chairman of the editorial board of RADIOPROTECTION the journal of the French radioprotection society (SFRP). He obtained Academic palms in 1992.

PhD John W. Stather is the Deputy Director of the Board and Head of the Research Division. He is responsible for the work of the Physical Dosimetry and Radiation Effects Departments and the Board's Service Centres in Leeds and Chilton.

After obtaining his first degrees in the Biological Sciences at Reading University he obtained a Masters degree in Radiobiology and then a PhD at the University of Birmingham. He joined the Medical Research Council, Radiological Protection Service in 1968 and transferred to NRPB when it was formed in 1971. He became Head of the Biomedical Effects Department in 1986, he was promoted to the post of Assistant Director in 1990 and to his present position in 1997.

His research work has been mainly concerned with radiological protection problems associated with the biokinetics, dosimetry and risks associated with intakes of radionuclides. He has been involved in studies related to the movement of radionuclides through the foodchain, and assessments of the health effects resulting from their discharge into the environment. He has also been responsible for work related to the dosimetry and effects of non-ionising radiations, in particular electromagnetic fields and ultraviolet radiation.

He has acted as a consultant to the CEC on the toxicity of radionuclides and their behaviour in the environment and was a member of a Task Group of Committee I of ICRP on deterministic effects of radiation. He has been a consultant to UNSCEAR (1989-2000) and to the IAEA; he is vice-chairman of ICRP Committee II and chairs an ICRP Task Group on internal dosimetry of radionuclides; he is a Vice-Chairman of the European Late Effects Project Group. He was a member of a Scientific Advisory Group to the CEC Radiation Protection Programme (CGC); he is an Assessor to NRPB's Advisory Groups on Ionising and Non-ionising Radiation; and was Secretary to the Independent Expert Group on Mobile Phones that reported in May 2000 He has published widely in his fields of study and has given invited lectures at scientific meetings on environmental and radionuclide dosimetry as well as on the effects of ionising and non-ionising radiation.

Professor, PhD Terttu Vartiainen is presently working in the Academy of Finland, Research Council for the Environment and Natural Resources. She is research professor at the National Public Health Institute (KTL) and a professor at the University of Kuopio. At KTL she is the Head of the Chemistry Laboratory with particular responsibilities for the safety of drinking water and health effects on humans of chlorinated persistent pollutants. Her studies cover two different research areas: 1) the chemical quality of drinking water, disinfection by-products and their health effects on the Finnish population, and 2) to dioxins and PCBs in the environment, food and humans and their health effects. Her main teaching area at the University is Environmental Chemistry.

After studying Organic Chemistry, Mathematics, Physic and Theoretical Physic at the University of Helsinki where she obtained her Masters Degree in Analytical Chemistry, she received her Ph.D. in Environmental Chemistry at the University of Kuopio. Since 1998 she has been chair of the Research Council for Environment and Natural Resources at the Academy of Finland where she will continue for another three-year period as the chair of the same council, now renamed the Research Council for Biosciences and Environmental Research.

She has been supervisor for 10 theses and has 9 doctoral students under her supervision. Her laboratory has a staff of 22 persons, of whom three are chemists and 6 technical assistants working with external funding. Her publications include 110 peer reviewed articles in international scientific journals, 50 international peer reviewed extended abstracts, 55 peer reviewed articles in national journals or conference reports, 37 reports in Finnish, and about 130 congress abstracts (in English) (articles in newspapers not included). She is member of the Finnish Chemical Society, Finnish Toxicology Society, Nordic Environmental Mutagen Society, Finnish Environmental Sciences Society, East Finland Chemical Society, Nordic Council of Ministers, Process and Laboratory Engineering, Expert group of Metrology, Finnish Mirror Task Force Group, European Science Foundation, Standing Committee for Life and Environmental Sciences (LESC), European Environmental Research Organisation (EERO), Advisory Committee *Network of Water and Sea*, and Chairman of the Management Board of the Finnish Environment Institute.

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Summary and Principal Recommendations

Research is essential to underpin the effective functioning of STUK and the quality of its advice. The need for research to support the work of STUK is not in dispute; where it should be performed is, however, more open to question. In principle, some or all of the research could be outsourced with STUK maintaining only a commissioning and monitoring role. The Panel concluded, however, that any move in this direction should be strongly resisted. Maintaining a considerable level of research within STUK was judged to be essential for acquiring and maintaining expertise, especially in emerging areas, and for attracting and keeping well-qualified staff. In its absence, a gradual decline in competence would inevitably occur, in particular in a field that is now relatively mature and, consequently, less appealing to young scientists. The Panel took the view that the current balance between different parts of the in-house research programme was broadly appropriate but that it should be kept under review. Most of the in-house research should have a "problem-solving" focus targeted at practical problems in radiation protection; active involvement in new and emerging fields should also be encouraged, in particular in areas were STUK may, in future, have to develop advice or guidance. Maintaining a flexible and responsive approach will be essential for the effective deployment of the internal research effort. The Panel noted that there was an apparent lack of independent scientific scrutiny of the research programme. The present review was the first that had taken place. It was felt important that programmes of research developed in house and the priorities set should be independently assessed, as this would substantially strengthen the laboratories standing and should ensure that a challenging and relevant programme was sustained.

The major recommendations of the Panel are:

Management Issues

(i) **to establish an independent international standing advisory group or to perform regular peer reviews to advice STUK and its stakeholders on its research priorities and strategies, and its internal organisation;**

(ii) **to review the programme of work of the laboratories to ensure an optimal size and to ensure units working in neighbouring fields with similar technologies complement each other;**

(iii) **to develop a proactive policy to succession planning that will ensure that specific knowledge essential to the provision of advice and the continuation of its research programme is retained in the organisation;**

(iv) **to further formalise and develop academic links with universities and training of students and young scientists to enhance career opportunities and the attractiveness of STUK and radiation research in Finland;**

(v) **to seek opportunities for involving senior scientific staff of STUK in the work of international organisations such as UNSCEAR, ICRP, WHO and ICNIRP.**

Generic Scientific Issues

(i) a carefully targeted programme of research should be developed. The multidisciplinary nature of radiation protection research does not allow an institution of the size of STUK to cover all aspects of importance for its advisory function and programme delivery. The strategic development of STUK's programme selection should therefore:

- be assessed regularly as to its appropriateness in a changing environment
- be based on importance and mid- and long-term potential to support STUK's mandate
- be harmonised with research in other national and Nordic research institutions to optimise research effort and synergism
- take into consideration personal expertise and equipment available at STUK, and guide succession planning ;

(ii) concentrate on areas where there is a specific need and an original contribution from Finland and other Nordic countries;

(iii) build on the existing collaboration with other Nordic countries to optimise efficiency and to allow effort to be directed to fewer activities by sharing tasks of minor importance;

(vii) to define the role of STUK and the benefits to be gained by its participation in European research activities;

(viii) to regularly review the balance between service based activities and research to ensure an optimal preservation and build-up of STUK's expertise in areas of long-term interest;

(ix) to seek to publish more of the organisation's research findings in high quality international peer reviewed journals;

(ix) to regularly evaluate the volume of external services in view of its impact on STUK's research activities.

Specific Scientific Issues

Department of Research and Environmental Surveillance

The Panel recommends that:

(i) the number and responsibilities of the laboratories be assessed in view of the creation of larger units and pooling of related technologies;

Management Unit, Emergency Preparedness

The Panel recommends that:

(i) STUK in its implementation of RODOS stays aware of the importance of:

- better understanding the needs of decision-makers at different stages in the management of radiation accidents, and how best to allow for uncertainties in model prediction
- a minimal harmonisation with neighbouring countries using different systems, and

organisation of and participation in emergency exercises of both scientific and administrative staff members;

(ii) STUK clarifies the role and expected outputs of RODOS in the response to a real radiological emergency in Finland;

(iii) co-operation with other research groups inside STUK is sought to improve a weak publication record.

Natural Radiation

The Panel recommends that:

(i) the mature projects in the areas of indoor radon exposure and radioactivity in drinking water be retained at a high level;

(ii) a common approach to the assessment of chemical and radiological toxicity of uranium is further developed;

(iii) work on assessing exposure to radon throughout Finland and the development of remediation techniques in conjunction with local authorities is a priority,
efforts to maintain a high profile in the media of the need to reduce high levels of domestic exposure to radon is maintained, and
the laboratory works closely with the Radiation Hygiene laboratory and external groups to develop methods for measurement of ^{210}Po and ^{210}Pb to be used for assessing historical doses from radon exposure;

(iv) the management clarify the amount of effort to be spent on research and on services related work to aid future planning of the programme.

Radiation Hygiene

The Panel recommends that:

(i) the laboratory's core activities, which are of great importance for STUK, Finland's nuclear industry and the radiation protection system, are maintained at least at the present level;

(ii) long-term monitoring of critical fission products in the unique Finnish environment is maintained to allow to achieve a realistic and comprehensive assessment in the event of future accidents involving the release of radionuclides into the environmental, and
this work be complemented by studies to examine sources of activity in the national diet;

(iii) emphasis is placed on publishing unique data sets held by the laboratory;

(iv) efforts to provide information to the public are kept at a high level to maintain the credibility of STUK as an authoritative and impartial body giving advice on radiation protection issues in Finland;

(v) work on the dynamics of sediment contamination is fully exploited.

Nuclear Power Plant Environment

The Panel recommends that:

(i) to achieve critical mass and to exploit potential synergism in analytical activities, close collaboration, concentration of radiological analyses in one laboratory, or integration with the laboratory "Ecology and Food Chain" is considered;

(ii) consideration should be given to capacity building, e.g. by the funding of research students from income obtained from providing services for nuclear power plants;

(iii) STUK should aim to publish data on the Baltic Sea biota obtained in the EU sponsored project, and the expertise developed in relation to the movement of radionuclides in sediments be exploited further to achieve a higher profile.

Ecology and Food Chains

The Panel recommends that:

(i) the number of projects is reviewed, prioritised and then reduced to achieve a critical mass for the remaining experimental activities and the proper dissemination of their results;

(ii) sharing of radionuclide analysis services with other laboratories inside STUK be considered;

(iii) Finnish strengths such as studies on forest ecosystems are further developed as a contribution to the global radiation research community;

(iv) new international efforts to assess doses and risks to critical groups of fauna and flora are supported with the aim of protecting the Finnish environment.

Airborne Radioactivity

The Panel recommends that:

(i) the relative importance of doses and risks from airborne particulate radioactivity, i.e. "hot particles", be re-evaluated, and activities reclassified correspondingly;

(ii) the benefits of the UAV project should be justified in more detail and compared to STUK's needs in other areas, and
effective lines of communication with other countries be maintained so that information is quickly shared between countries;

(iii) sharing of radionuclide analysis services with other laboratories inside STUK be considered.

Regional Laboratory in Northern Finland

The Panel recommends that:

(i) given the uniqueness of the laboratory and an international need for radiological data in the context of arctic contamination, the personal capacity be strengthened;

(ii) international funding be considered for activities concerning the Kola peninsula an the radiological legacy of the former Soviet Union.

Medical Radiation

The Panel recommends that:

(i) research and support work for the implementation of the European Medical Exposure Directive is given first priority;

(ii) direct measurements of doses from diagnostic procedures performed in Finland are carried out to improve the basis for the establishment of reference doses for diagnostic procedures;

(iii) training in medical physics related to diagnostic radiology should be enhanced to redress a lack of specific Finnish information on doses received, and international contacts in this area be strengthened;

(iv) QA methods and audit procedures should be further developed, if appropriate with other Nordic countries;

(v) further research on boron neutron capture therapy should be dependent solely upon clinical requirements;

(vi) the development of software for the assessment of risk from radiation exposure should be transferred to the epidemiology group.

Radiation Biology

For Epidemiology

The Panel recommends that:

(i) epidemiological studies being carried out should be reviewed and those that are not essential to the priorities of STUK should be discontinued;

(ii) consideration should be given to carrying out an epidemiological study on skin cancer in users of solaria;

(iii) collaboration with other laboratories is essential and should continue.

For Radiation Biology

The Panel recommends that

(i) the radiobiological activities of STUK, which are unique and original in the Finnish context, should be maintained at the international level and concentrated on risks where the local exposure situation or the average sensitivity of the population allow for highly original work at the international level;

(ii) basic research on mechanisms of carcinogenesis should be pursued to the extent that it is necessary to maintain competence and public confidence in STUK as a state of the art professional body in radiation protection;

(iii) biological dosimetry and work on indicators of exposure should be maintained and further developed with international partners as a core activity of STUK;

(iv) research should continue to better understand health effects of exposure to ultraviolet radiation;

(v) molecular and cellular studies designed to understand any possible effects of exposure to RF radiation should be kept under continuous review to ensure they are consistent with research priorities.

Department for Radiation Practices and Regulations

Radiation Metrology and Dosimetry

The panel recommends that:

(i) regulatory and dosimetric optimisation of the safety of radiation therapy is maintained as a central mission of STUK;

(ii) major efforts to improve boron neutron capture therapy (BNCT) be dependent on

a clinical – and hence regulatory – need in this area in Finland;

(iii) national competence in new calibration techniques are developed and disseminated.

Non-Ionising Radiation Laboratory

The Panel recommends that:

For UV

(i) monitoring of solar radiation should continue;

(ii) the development of improved methods for measuring exposures from sunbed use is desirable;

(iii) the provision of information to the public on health effects of UVR is a priority.

For EMF

(i) the laboratory should take the lead in establishing an agreed testing procedure for assessing the SAR of mobile phones and publishing the information for phones available in Finland on its web site;

(ii) further monitoring of exposures from base stations is likely to be needed for public reassurance that there is compliance with guidelines;

(iii) research by STUK on possible health effects of RF radiation from mobile phones should be seen to be independent;

(iv) the number of activities supported by the laboratory should be kept under review;

(v) opportunities should be sought to share information and metrology development with other Nordic countries.

Introduction

The Radiation and Nuclear Safety Authority (STUK) is a regulatory authority, research institution and expert organisation, whose mission is to prevent and restrict any harmful effects of radiation. The ultimate objective is to keep the radiation exposure of Finnish citizens 'as low as reasonably achievable' (the ALARA principle) and to prevent radiation and nuclear accidents with a very high certainty (Safety As High As Reasonably Achievable or the SAHARA principle). The confidence of the general public and stakeholders' views on the significance of STUK's operations in enhancing safety are also key indicators of the quality of its work.

A key objective of STUK's research is to extend professional knowledge that supports regulatory operations and the maintenance of emergency preparedness.

The research carried out at STUK is related to radiation protection. In addition, STUK experts also supervise nuclear safety research projects (safe use of nuclear power and nuclear waste management) commissioned by the authorities and conducted by organisations outside STUK. However, the present review only covers the strategy, organisation and results of radiation protection research carried out by STUK itself.

The Institute of Radiation Physics, the predecessor of the Radiation and Nuclear Safety Authority (STUK), was founded as a research institute in 1958. Its functions had been defined earlier, in 1957, in the Radiation Protection Decree. They were primarily to monitor the safety of X-ray equipment and other radiation sources used in hospitals, to carry out the necessary radiation measurements related to radiation therapy, and to study the consequences of atmospheric nuclear tests for human health and the environment.

In the early years of STUK, research focused on developing radiation metrology and personal dosimetry, and on radioecological studies in the environment. Wider use of radiation in medicine and industry in the early 1960s forced STUK to develop more accurate methods of calibrating X-ray and radiation therapy machines, and also to develop its own dosimetry system for personal dose control. On the other hand, atmospheric nuclear tests in the 1950s and early '60s generated public pressure for research on how members of the public are exposed to radioactive fallout and how different radionuclides behave in the Finnish environment. These radioecological studies also led to the establishment of a separate laboratory in northern Finland to study more closely the behaviour of radionuclides in sub-arctic food chains. The laboratory was founded in 1970 in Rovaniemi.

The first investigations on underground miners' exposure to high concentrations of radon and its progeny were performed in the 1970s. These studies led to regular monitoring of workers' exposure and guidelines for action levels, monitoring frequencies and mitigation measures were introduced. The first findings on exceptionally high levels of natural radionuclides in groundwater also date from the late '60s.

In the '70s, after a political decision had been taken to build nuclear energy capacity in Finland, STUK's resources were increased, giving it greater research capabilities. The main research areas at this period were the behaviour of radionuclides in the environment and their transfer to human body, but also the occurrence of radon and other natural radionuclides in underground and surface waters and in building materials, radon in houses and workplaces, and the development of new methods for radiation surveillance in the immediate surroundings of future nuclear power plants. The first experimental studies on radiobiology and non-ionising radiation were also carried out.

The nuclear accident at Chernobyl in 1986 had significant radiological consequences in Finland. The radioactive fall-out necessitated extensive investigations on public exposure to released radionuclides, the occurrence and behaviour of radionuclides in the environment, and on the effects on the health of exposed people. The need for experimental radiobiological research, use of modern biological dosimetry, and for epidemiological studies increased. More effort was put into developing of emergency preparedness tools, including automatic monitoring networks, environmental modelling and decision-aiding techniques. Research became more networked with domestic and foreign research institutes and the number of joint projects was increased.

STUK co-operates closely with other Nordic countries, Sweden, Norway, Denmark and Island in radiation protection research. This co-operation can be said to have started even before the official establishment of STUK, that is, in 1957, when the Nordic Liaison Committee for Nuclear Energy Questions (NKA) was set up. Nordic research co-operation moved into a new phase in 1975, when a new co-operation forum, Nordic Nuclear Safety Research (NKS), was established. This co-operation takes place within four-year framework programmes.

The collaboration with the New Independent States of the former Soviet Union, especially the Baltic States, and Eastern European Countries increased considerably in the 90's, especially in nuclear safety but also in research related to the environmental and health effects of the Chernobyl accident and the former nuclear tests. The establishment of the National Data Centre related to the Comprehensive Nuclear Test Ban Treaty also promoted new research functions in the late 90's. At present, in addition to domestic and Nordic co-operation, STUK plays an active part in European Union research programmes, and engages in bilateral and multilateral research co-operation with countries such as the United States, Russia, Japan and Estonia.

Summary of Present Research Activities

STUK’s research activities relate to radiation in man and the environment, health effects of radiation and the prevention of hazards caused by radiation. At present, research activities of STUK cover radiation biology and epidemiology, natural radiation, radioecology, radiation hygiene, medical use of radiation, dosimetry, and non-ionising radiation. Maintaining an effective preparedness for field and laboratory measurements in order to cope with abnormal radiation situations is an important part of research activities.

Biomedical research deals with the effects of radiation on man. STUK has broad scientific expertise ranging from molecular biology to epidemiology and covering both ionising and non-ionising radiation. Main lines of research are radiation epidemiology (eg. radon, Chernobyl fallout, mobile phone radiation, solar UV), biodosimetry, genetic effects studied by minisatellite mutations, molecular changes in radiation induced cancer, radiation-induced genomic instability, effect of radiofrequency radiation on signal transduction end effects of UVA on tumour metastasis.

Research in the field of natural radiation started with studies of radon in mines and household water in the early 70’s. From the early 80’s a comprehensive survey of radon in houses has been carried out. Today STUK's indoor radon information system includes indoor radon concentration, geological data, coordinates and data on construction of more than 50,000 dwellings. The research activities of airborne and waterborne radon have involved nation-wide surveys, mapping, epidemiological studies, indoor radon mitigation and prevention techniques as well as water treatment methods for removing radionuclides from water.

Research activities involving non-ionising radiation include the development of measurement techniques required to determine radiation exposure, as well as exposure measurements, particularly in relation to UV radiation, microwave radiation and various electric and magnetic fields. In the last few years studies have been focused on exposure effects of mobile phones, development of SAR measurement methods, development of irradiation systems for animal and cell culture studies and the use of solaria and resulting UV doses as well as clarification of biological effects of UVA and mobile phone frequency radiation.

Radioecological studies aim at the modelling of the transfer of radioactive substances in the environment and estimation of the subsequent radiation doses to man. Special attention is given to the semi-natural environments and forest industry.

Research on radiation hygiene deals with kinetics of radionuclides in human body and with the consequent internal exposure to radiation. Concentrations of radionuclides in human body are monitored with whole body counters and using other bioassay methods.

Development of tools for emergency preparedness includes surveillance methods needed in monitoring of radioactive substances as well as comprehensive decision support systems for nuclear emergency preparedness. Mobile systems as well as fixed stations for radiation monitoring are developed. Sophisticated analytical methods for sample analysis are developed especially from the point of view of characterising individual radioactive particles present in the sample.

Current research on medical use of radiation is mainly focused on projects supporting the implementation of the European Medical Exposure Directive, such as optimising X-ray diagnostic and interventional procedures, exposure of the most radiosensitive patients (children), screening of non-symptomatic patients (mammography) and determination of patient doses and radiation risks. In the field of radiotherapy, the studies are focused on the safe use of radiotherapy, such as dosimetry of boron neutron capture therapy (BNCT).

Background to the Evaluation

The objective of this peer review was to provide an evaluation for the Ministry of Social Affairs and Health of the research and health physics functions of STUK. Scientific merit and cost-effectiveness of the recent scientific work undertaken, as well as the proposed objectives, outputs and outcomes of future work were considered. The review covers all professional activities with a research component of the two units “Department of Research and Environmental Surveillance” and “Department for Radiation Practices and Regulations”. The evaluation also served to consider the positioning of STUK in the Nordic, European and world-wide context of radiation research and protection. Details of the evaluation methodology, the terms of reference and membership of the Panel are found in Annexes A, B and C.

The Panel considers it of utmost importance to further outline the work undertaken and its limitations as follows:

- although this evaluation is comprehensive, the findings of the peer review team have to be considered strategic and overarching in nature in view of the many projects reviewed. The review centres on an assessment of the overall scientific achievements and future projects of STUK, and of the positioning of the institution and its programmes in the national, Nordic and international radiological research environment.
- the Panel has not reached in depth judgements on research allocation within STUK’s research programme, but has made some general recommendations for reallocation of resources. This report can therefore not be considered a detailed audit of human and financial resources within STUK.
- in view of the interdisciplinary nature of STUK’s research activities, the review team has put great emphasis on the national and international context and the potential for sharing of responsibilities in preserving a healthy and professional environment for Finland’s needs in radiation protection. The effective discharge of the mission of STUK requires an active pursuit to establish and maintain interfaces with the Ministry and other public sector institutions.

Review of Institutional Objectives and Responsibilities

MISSION OF STUK

The Radiation and Nuclear Safety Authority (STUK) is a regulatory authority, research institution and expert organisation, whose **mission is to prevent and restrict any harmful effects of radiation.**

The ultimate quality objective of the operations is to keep the radiation exposure of Finnish citizens as low as reasonably achievable (the ALARA principle) and to prevent radiation and nuclear accidents with a very high certainty (Safety As High As Reasonably Achievable or the SAHARA principle). The key indicators of the quality are also the confidence of the general public in STUK’s ability to perform the task it has been entrusted with, and the radiation and nuclear energy users’ views on the significance of STUK’s operations in enhancing safety.

DEVELOPMENT OF RESEARCH POLICY AND STRATEGY

The scientific strategy is based on STUK’s mission: to prevent and limit any harmful effects of radiation. For this purpose, research is carried out on radiation measurements and levels, on effects of radiation and on prevention of radiation hazards.

STUK's current strategic plan was defined in 1998 and covers the programme of work for the next four years to 2002. Since then, all departments have prepared more detailed strategic plans of their own. Once fully developed, these departmental strategic plans will include a description of their mission and a vision for the future, an evaluation of changes in the internal and external operational environment (in the form of a SWOT analysis), and plans for different areas of work.

The strategic plans are reviewed annually and revised jointly by management and staff, so that the planning period is always four years ahead. Research strategy is part of departmental strategy, and none of the departments under evaluation carries out research alone. There is continuous input from other functional sectors, such as emergency preparedness, environmental surveillance of radiation and regulation of radiation practices which ensures that the research carried out supports the other functions of STUK.

When STUK decides which new projects are to be prioritised and funded, the following factors are taken into account:

- lack of knowledge in the specific area

- importance for public health: which takes into account whether large numbers of people are exposed and the potential for /large individual doses

- national importance and any special features for Finland

- social demand for the knowledge

STUK’s research mission is to prevent and limit the harmful effects of radiation. The foundation for this is to gain information on the health risks for members of the public and persons who are occupationally exposed to radiation. As knowledge about the radiation exposure and associated risks grows, more emphasis will be placed upon prevention and limitation.

STUK is the leading – and in most areas the only - national organisation conducting radiation protection research in Finland. At the European level and even on a world scale STUK is among the top research institutions in its field. This is largely due to the multidisciplinary know-how, in depth understanding and insight into the practical implementation of results of its research in order to support the whole organisation's mission. STUK has research contacts with more than one hundred research institutes in more than thirty countries.

At the national level, STUK's research networks involve eight universities and technological universities and all major governmental research institutions dealing with health, environment and foodstuffs, as well as a number of technological research centres. Technical development has been carried out with several companies and a number of domestic collaborators have acted as suppliers of samples and data.

During the last five years, STUK has been involved in about 40 research projects and concerted actions funded by the European Union. In several of these, STUK has acted as co-ordinator. At the national level, the most important sources for external research funding have been the Academy of Finland and the National Technology Agency (TEKES). The external funding of STUK has increased from 3,440,000 FIM in 1995 to 8,060,000 FIM in 1997, but is still at a small level. The main funding is provided by the state budget, guaranteeing continuity and a basis for long-term planning of the organisations activities.

For this scientific evaluation of STUK research, two reports were prepared describing research projects of STUK 2000-2002 (STUK A-179, Salomaa, ed.) and research activities of STUK 1995 - 1999 (STUK-A-180, Salomaa and Mustonen, eds.). The reports provide an up-to-date review of the scientific strategy, organisation of research and scientific output of STUK. These two reports were continuously referred during the current evaluation.

As there are no other major domestic research organisations in the field of radiation protection, the research collaborations developed by STUK have been mainly directed towards foreign institutions. These have included e.g. IARC, IAEA, CTBTO, Harvard University, the US National Cancer Institute and the UK National Radiological Protection Board. Regular exchange visits are arranged with many Laboratories in Nordic States and with research groups in the former Soviet Union.

As part of the realisation of the European Research Area, STUK's vision is to be included among the European Centres of Excellence in the field of radiation protection research. This will mean taking a leading role in the Nordic/Baltic area and an increased number of joint research projects and foreign researchers working at STUK.

STUK’s mission is to prevent and limit any harmful effects of radiation. The research conducted at STUK yields new information related to the use, occurrence and effects of radiation. Research is the main single activity of STUK. Each year about 70 person-years are invested in research. The annual research costs of STUK are currently 37 million FIM (6.3 million EURO). Other activity sectors of STUK are: nuclear safety, radiation safety, emergency preparedness, environmental surveillance, external services and communication. STUK has adopted the Quality Management system. The main laboratory functions were accredited by FINAS in 1999 (T167/EN45001). STUK is the national standard laboratory for ionising radiation quantities. Since 1997, STUK has acted as a WHO Collaborating Centre for Nuclear Emergency Preparedness.

The research facilities of STUK are excellent by any international standards. The new premises for STUK were built 1994 in Roihupelto, East Helsinki. This provided not only new laboratory facilities and equipment, but perhaps more importantly, brought together a critical mass of experts that previously had worked at separate sites all over the Helsinki area. Bringing together all the main groups covering fields of radiation and nuclear safety expertise creates a strong synergy benefit. Outside Helsinki, STUK has one regional laboratory in Rovaniemi, which specialises in sub-arctic and arctic ecosystems.

The information services section at STUK includes a high-quality library, which acts as the central library for radiation and nuclear literature in Finland. Online scientific databases are readily available via an internal computer network and STUK has its own web site that provides scientific and technical information. It includes information for the public with an interactive section, which allows questions to be answered on line, and some question and answer sheets.

A majority of the scientists involved in the research programme are working at the Department of Research and Environmental Surveillance. Additional expertise in e.g. dosimetry and exposure systems is provided by the Department of Radiation Practises Regulation. The cohesiveness of the research groups is high, including joint strategic and annual planning and joint scientific seminars.

The research teams include senior scientists and postdoctoral researchers as well as doctoral students and research assistants. Most of STUK's scientists have extensive experience. As many of them were recruited in the 1960's and 70's and will retire during the next few years, a new generation of experts needs to be educated and succession planning is important for the future well being of the organisation. External project funding and post-graduate training have already proven to be an efficient means for guaranteeing the transfer of knowledge and experience in several areas. However, it could be necessary to formalise this replacement of staff, e.g. by allowing overlapping of the work programmes of outgoing and incoming specialists in areas with a highly specialised function. In addition to STUK's own needs, there is a continuous national need for expertise in assessing radiation risks and environmental impacts in several other governmental bodies and research institutions.

THE INTERFACE WITH THE MINISTRY OF SOCIAL AFFAIRS AND HEALTH AND WITH OTHER NATIONAL STAKEHOLDERS

The Ministry of Social Affairs and Health has overall responsibility for research and development in its sector. Besides STUK, this task encompasses three other research institutes, the KTL (National Public Health Institute), the STAKES (National Research and Development Centre for Welfare and Health) and the FIOH (Finnish Institute of Occupational Health). There are important and formal interfaces between these three, e.g. through two meetings per year convened by the Ministry, which bring together senior officials of the Ministry and the Heads of the institutes. The Panel recognises that areas such as radiation epidemiology and recent developments in molecular biology including studies on individual sensitivities and susceptibilities to genotoxic agents might profit from close interactions between STUK and research in the public health sector.

Since ionising radiation and UVR are probably the most important genotoxic agents in the natural and man-made environment (active smoking, an even more important public health problem, results from a mixture of many genotoxic and non-genotoxic toxicants), an inclusion

of STUK in all generic national activities in the area of public health is warranted. A modern and holistic approach to risk assessment and remediation strategies has to compare for example:
– indoor radon with asbestos, and
– actinide series radioactive elements with heavy metals and chemicals in drinking water.
A proposed broadly based national public health forum might be an efficient mechanism to link up such activities.

The Panel recommends that:

(i) the Ministry should regularly scrutinise and - if necessary - redefine the responsibilities of STUK and foster efficient interfaces within the research system in and outside of the responsibility of the Ministry of Social Affairs and Health;

(ii) STUK should be represented on the proposed national public health forum to ensure sufficient alignment of strategic planning in areas of mutual interest;

(iii) the harmonisation of protection philosophies and regulations for conventional toxicants, ionising radiation and UVR should be actively pursued by the Ministry of Social Affairs and Health.

INTERFACE WITH UNIVERSITIES AND RESEARCH INSTITUTIONS

Several of STUK's scientists have posts as university lecturers. Universities and technical schools send a number of students to STUK for training each year. STUK's scientists supervise several Master's theses annually. An average of 1-2 post graduate level degrees (PhLic or PhD/DrTech) are completed each year. STUK supports postgraduate studies by supervising theses, allowing time for related studies and organising training itself. Currently, altogether 31 employees of STUK have registered as postgraduate students or expressed their interest for post-graduate education. Due to the diverse field of expertise and training needed for radiation protection, no special graduate school has been established in radiation protection so far. The strategy has been to take part in other graduate schools on a case-by-case basis, and gain complementary expertise in addition to radiation protection.

Much collaboration on specific projects exists between scientists of STUK and colleagues in universities, which are based on shared or complementary interests. For specialised areas in radiation research where there are no independent national activities at the university level, or where STUK complements activities with original contributions, the establishment of joint professorships between STUK and the universities should be explored. Potential areas for such arrangements are radiation epidemiology, radiation ecology, and biological indicators for genotoxic agents,

The Panel recommends that:

(i) the strong links with universities are maintained and strengthened;

(ii) teaching activities by STUK’s staff members should be encouraged and be considered as a part of strategic planning when appointing new staff;

(iii) the establishment of joint professorships for core scientific activities in radiation research should be considered for areas where no national academic activities exist;

(iv) **the progress of the employees of STUK registered as postgraduate students should be strictly followed. The time to be spent for completion of a thesis degree should not exceed three to five years.**

INTERNATIONAL COLLABORATIONS

STUK's activities at the international level are considerable. Notable are professional activities within the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden), the former Soviet Union and especially the Baltic States. Finland is a member of the European Union since 1995 This has permitted STUK to be strongly involved in the 4th and 5th Framework programmes of the EU. Today there is full integration of STUK into the European radiation protection community. An even stronger involvement in newly emerging programmes should be envisaged. Given the size of Finland and the many disciplines to be covered for a comprehensive radiation protection, **the Panel recommends that efforts to rise the international profile of STUK are strengthened by:**

(i) exploiting synergism from co-ordination and division of tasks within the Nordic countries, especially for problems specific to this area such as sub-arctic food webs and high sensitivity to UVR;

(ii) enhancing visibility by contributing to UNSCEAR, eventually via the Swedish membership, or by redefinition of Nordic countries membership, replacing Sweden membership by Nordic member states membership, and by attending conferences such as the US NCRP annual meeting;

(iii) fund raising through professional contributions to and co-ordination of research projects of EU/Euratom;

(iv) assisting the Baltic States and Republics of the former Soviet Union in remediation of the nuclear legacy of the former Soviet Union.

TRAINING AND CAREER DEVELOPMENT

STUK has no national partners with equal professional status and local universities do not provide comprehensive graduate and post-graduate training in the scientific disciplines needed for radiation protection. Clinical expertise in the area of radiology and nuclear medicine is found in university hospitals but a lack of medical physicists in the area of diagnostic x-rays is noted. Members of the staff of STUK act as supervisors for a number of graduate students, and several senior staff members teach outside STUK.

The Panel recommends that:

(i) in-house activities are maintained and further developed to train young professionals on the job;

(ii) seminars on scientific developments in the area of radiation research are offered to staff on a regular basis, and considerations of training and career development contribute to decisions on international collaboration and conference attendance;

(iii) STUK should make contacts internationally, enhance training at the national level, and work towards the creation of positions to overcome the local lack of medical physicists in diagnostic radiology.

DISSEMINATION AND EXPLOITATION OF RESEARCH

High-quality scientific publications are the key product of STUK's research. They also form a solid basis for the conclusions and recommendations passed on to decision-makers and citizens. The highest-quality results are submitted to international peer-reviewed journals for publication. Studies that are of interest mainly at the national level are published in national report series in Finnish and/or Swedish.

Although STUK carries out a considerable amount of technical development work, relatively few patents have been registered so far. Over the years, there have been a few spin-off enterprises established by former employees.

The research carried out at STUK is applied, and many of the results are of interest to citizens, decision-makers and stakeholders. STUK's information policy is open and proactive. In the case of research results, the routine procedure is to pass a popularised summary of the results to the Information Unit immediately after publication. Training of scientists includes instruction on communicating with the media and this is also practised in connection with emergency exercises. Citizens are very interested in news dealing with radiation and nuclear safety, and the media takes an interest in practically all STUK's press releases.

The Panel recognises that the number of STUK's publications in peer reviewed international journals is generally very high and provides high international visibility to the Finnish radiation research activities. These scientific papers are the source of credibility of STUK's staff members. At the level of the citation index ranking of the journals used, the impact seems less impressive, but this is mostly a consequence of the fact that STUK's activities are in a highly specialised areas, and not a lack of excellency of STUK's research efforts.

The Panel considered that the efforts and results of STUK's dissemination and exploitation of its research to the general public are to be commended and this is a very positive aspect of STUK policy. If compared with other European countries, public acceptance of these activities appears to be high for this difficult area. The involvement of social sciences and the relatively small size of STUK seem to have helped in a holistic and pragmatic approach.

On a more specific level, the Panel wants to stress the importance of recreational behaviour on skin cancer risk. The potential for avoidance of unnecessary UVR exposure through public information campaigns in a generally fair skinned population with a high cancer risk from intensive sun exposures at home, but especially abroad during beach holidays, is evident. Above average indoor radon exposures and actinide concentrations in drinking water are also considered potential targets for public awareness campaigns.

The Panel recommends that:

(i) expected outcomes and societal benefits of research results are specified during programming;

(i) all necessary efforts are made to maintain a high output of peer-reviewed publications;

(ii) additional expertise from the disciplines of social sciences and communication is sought to improve the dialogue with the public on radiological issues;

(iii) educational efforts in the area of non-ionising radiation, and especially UV-radiation, are strengthened.

MANAGEMENT ISSUES

The Panel was not mandated, and not equipped to undertake a comprehensive review of the managerial arrangements of STUK. The following considerations are at the intersection of research planning and management proper, and might require consideration by the director of STUK and by the Ministry of Social Affairs and Health.

A relatively small and geographically isolated research institution like STUK, dealing with a highly interdisciplinary area, derives its strength from dedicated individuals and the support of research directors and laboratory heads. In the case of STUK, a single individual can make a big difference. Loss of human resources through retirement or other job opportunities is considered an important threat to the continuity of STUK's research efforts. At present, most public sector research institutions are heading towards an increase in limited time contracts at the expense of tenured positions. Although such a move will increase the flexibility of STUK to adapt to changing needs in the area of radiation protection research, some of the more specialised activities might suffer from such a policy.

The current management structure is reasonably flat and responsibilities seem to be delegated to the appropriate level. A reduction in the number of laboratories should be considered, especially where small unit sizes and similarities of techniques promise synergism. Administrative burdens to professional staff seem to be acceptably low concerning time requirements, and seem not to negatively impact on motivation.

In view of the fact that this Panel's review is the first comprehensive external attempt to assess the research activities of STUK, a review mechanism with a necessary degree of scientific rigour and independence should be implemented. Since there is little chance to recruit a local standing advisory committee with both enough independence from and professional knowledge of STUK, a regular exercise such as this international Panel's review might be envisaged. A strategy group made up by senior officials of the Ministry of Social Affairs and Health and STUK might be helpful to plan and overview the review.

The Panel recommends that:

(i) **a comprehensive review mechanism for the research activities of STUK be implemented, allowing for an independent international review at least every five years;**

(ii) **succession planning for senior positions is given due and continuous consideration;**

(iii) **consideration should be given to conditions of employment of professional staff which will balance both the need for flexibility which is essential for any research organisation, and for continuity in highly specialised activities of STUK.**

Review of Departments and Laboratories

Based on its terms of reference, the peer review team scrutinised those units with research activities, i.e. all laboratories of the Department of Research and Environmental Surveillance and the Radiation Metrology and Non-Ionising Radiation activities of the Department for Radiation Practices and Regulations. The question of balance and resource allocation between research activities and other functions not reviewed remains largely outside the scope of this report. It is however noticed that a strong interdependence exists between research and development activities and a “state of the art” implementation of radiation protection requirements.

DEPARTMENT OF RESEARCH AND ENVIRONMENTAL SURVEILLANCE

Introduction

The main objective of the radiation protection research of STUK is to provide and extend knowledge about radiation effects on human health and the environment and about the behaviour of radionuclides in our living environment. The goal is to support the mission of STUK, i.e. to prevent and restrict any harmful effects of radiation. In that sense, the achievement of STUK's research can be reviewed by looking at how the results have supported the regulatory activities of STUK and what new knowledge the research has produced.

Management Unit, Emergency Preparedness

A nuclear explosion or a serious accident at a nuclear power station in Finland or its environs may result in a hazardous radiation situation with effects that – at their worst – will have an impact on the whole of society. There is also the potential for many smaller accidents and incidents leading to local contamination and radiation exposure. To improve the ability to deal with nuclear emergencies, management and decision support systems need to be tested and countermeasures need to be studied and planned in advance. The tasks facing decision-makers in emergency management are complex and demanding. During an incident, large quantities of varied and continually changing data become available, risking an ‘information overload’. To improve its management of nuclear emergencies based on decision support systems, STUK has taken part in the work towards completion and customisation of the European RODOS (Real-time, On-line Decision Support System) system. This is a programme designed to model radiation accidents and can take into account monitoring data to provide support for decision makers. The overall objectives are to plan countermeasures in advance and to catalyse the development of future versions of decision-supporting systems that are better tailored to the decision-makers practical needs in terms of information provided and interface design.

Research and technical development of tools for nuclear emergency management also include automated and real-time monitoring of external dose rate and radioactive materials, mobile radiation monitoring devices (e.g. by aerial vehicles) with geographical positioning systems and wireless communication as well as research related to the release, characterisation, transport, dispersion and deposition of radioactive particles. The development of a trace radionuclide measurement laboratory function for the Comprehensive Nuclear Test Ban Treaty requires detection of very low level activities and verification of the origin of release.

Further information on the development of RODOS is given in the documents A179 and A180.

Personnel

The personnel consist of one senior and one post-graduate researcher, five secretaries, a statistician and a system analyst.

Main Comments

The work on RODOS has been a valuable collaborative exercise involving many European countries. It should provide a valuable tool to support decision-makers in the event of a radiation accident. The involvement of STUK in its development has provided staff from the laboratory with important opportunities for working with experts from other countries. The extent to which RODOS is used in any accident will depend upon the nature of any incident and the extent to which the programme has been developed. It will also depend upon the level of expertise available in STUK. If the political decision is to support RODOS then its use must be well exercised so that staff are familiar with its strengths and limitations and will be confident in using it if the need arises. The objectives of the government in the case of an emergency, and the resulting obligation for STUK have to be properly defined. A holistic response to a radiological emergency encompasses a number of different sciences, such as physical, social, etc., and STUK's involvement is mainly concerned with co-ordination at the national level.

Progress Report[1]

The participation of staff from STUK in this European activity is valued by all the European partners and is an important contribution to Finnish activities related to Nuclear Safety, especially at the crossroad of Western and Russian reactor design. The four objectives of the programme are all essential. The Panel considered that priority should be given to:

- better understanding the needs of decision-makers at different stages in the management of radiation accidents; and
- improvement of the level of communication about uncertainties to the decision-makers.

- Organisation of and participation in exercises should be a priority task for STUK and all staff members need have to participate so that the organisation is well placed to respond in the event of an emergency.
- STUK collaborators need to fully understand the factors influencing the choice of parameter values included in the RODOS system if they are to be involved in its implementation.

Future programs[2]

- Participation into the work of RODOS Users' Group will need to continue if the further development of this programme is to be taken forward by Finland. The Group should be

[1] Research activities of STUK 1995-1999, STUK A 180, August 2000, p43-49
[2] Research projects of STUK 2000-2002, STUK A179, June 2000, p75.

asked to propose a list of stakeholders involved in these actions and to propose new actions.

- Participation of STUK is also absolutely necessary in the European program DSSNET (Improvement, extension and integration of operational decision support for emergency management).

Publications

- There are 7 publications listed, 3 as STUK reports, 3 in conference proceedings and one in a refereed journal with a laboratory member as a first author. In addition, the group also participates in the preparation of RODOS documents.

Comments

Some European Union member states have implemented the RODOS system in their national emergency preparedness system; Finland is one of them. Finland actively participates in its diffusion to European Union candidate countries. On the other hand, several other EU member states do not plan to use RODOS in the event of an accident. Sweden, an active member of the Nordic association, belongs to this group. A third group, which includes France, continues to use a national system and uses RODOS for comparison, validation and general studies only. This may cause acceptance problems by the public in the event of an emergency unless these different positions are clear. A European evaluation of the different positions would be useful.

STUK has to recognise:

- that a unequivocal demonstration of the potential use of the RODOS system in a real accident situation is not yet established.

- that Finland today needs a robust system, waiting for an operational version of RODOS. Robustness here means stability against computer failure, and input of Finnish geographical and population data into models used at present.

Recommendations

- If the development of RODOS is to be a key priority, then a better understanding is required of the needs of decision-makers at different stages in the management of radiation accidents and how best to allow for uncertainties in model prediction.
- STUK in its implementation of RODOS should collaborate with neighbouring countries in relation to accident preparedness.
- The organisation of and participation in emergency exercises should be a priority task for STUK. All staff members, both scientific and administrative, need to participate so that the organisation is well placed to respond in the event of an emergency.
- Co-operation with other research groups inside STUK to improve a weak publication record.

Natural Radiation

Due to the high uranium content of bedrock and soil and the local climatic conditions, Finland is among the countries that have the highest radon concentrations in indoor air. Moreover, the groundwater contains high concentrations of uranium and radon. Exposure to natural radiation due to elevated radioactivity concentrations in both indoor air and household water increases the risk of cancer. The objective of the STUK programme is to quantify risks and to develop techniques for reducing exposure to natural radiation. Some of the pioneering work in domestic radon exposure has been done in STUK and the extensive databases on levels in homes in radon-prone areas with information on a number of geological and construction parameters provides an excellent basis for studies on radon mitigation.

For radon in indoor air, the future research priorities include: exploring the effect of house construction, soil and geological factors; evaluation of retrospective radon measurement methods; development of radon-safe construction methods; and participation in multi-national risk assessment studies.

For radioactivity in household water, the key areas of research are: studies on the influence of bedrock type and water quality on radionuclide levels; assessment of human exposure to lead-210 and polonium-210; monitoring of radon transfer from household water to indoor air; and development of water treatment methods.

Personnel

There are seven researchers of which one is a senior scientist, supported by five laboratory operators. Also the age distribution is considered good for preservation of knowledge.

Main comments

The work of this laboratory on exposure to natural radiation is concerned with works for a major radiological program of concern to STUK and to Finland. This is an issue of public concern and its staff are in permanent contact with the public, media and national decision-makers. The level of scientific effort and the quality of the work being carried out are consistent with the best international research work in this field.

Progress report[3]

1. Radon risk mapping.

As with many countries in Europe with a potential for elevated indoor radon levels, Finland needs a map of radon levels in dwellings. This permits national authorities to recommend priorities for further measurements and allows more precise risk assessment. The map developed by STUK has beenn placed on the Internet web site of STUK to provide general information for the public. From the prospective method of analysis adopted for the national survey, the probability of exceeding the action level of 200 Bq/m^3 is calculated for the house type at the highest risk in each sub-area and soil type.

2. Radon-safe building.

Co-operation between STUK and the building and health authorities is good and needs to continue. The European recommendations related to domestic radon exposure are based on the Finnish guidelines (ST Guide 12.2) and on the survey and proposal provided for the European Commission by STUK. This demonstrates the international level of the laboratory's activities.

3. Remedial measures and prevention studies

The radon project developed by STUK is supported by the work on remedial measures, which clearly demonstrate the maturity of the program of work.

[3] Research activities of STUK 1995-1999, STUK A 180, August 2000, p

These three parts of STUK's radon program clearly demonstrate the level of excellence of the work in this laboratory.

4. Surveys of radioactivity in household water, doses from drinking water, and remediation

The laboratory has been conducting a systematic survey of natural radioactivity in household water since the late '60s. This is still of radiological significance because the bedrock waters are an important source of drinking water in Finland. The mean dose received through ingestion of drinking water is calculated to be 0.14 mSv per year, which is relatively high. Population groups of considerable size can receive an annual dose of more than 1 mSv from ingestion of radionuclides in drinking water.

Comment: This activity is complemented by health studies carried out by the radioepidemiology group. The Panel encourages the continuation of the survey of population groups drinking water with high content of uranium and other natural radioisotopes.

Future projects[4]

The future program of work on natural radiation is ambitious but with present staff numbers this should be readily achieved. It is important to complete indoor radon mapping for the Ministry of Health and it is necessary to develop collaboration with local authorities, particularly in relation to providing advice on remediation measures.

Radon levels in indoor air depends on many structural and geological factors and there are temporal variations. This is well recognised and STUK benefits from collaboration with other European member states in the comparison of different approaches. This could be done for example in the framework of EC programmes and in bilateral agreements as for example in the memorandum of understanding between STUK and IPSN. Similar considerations also apply to remediation of radon levels in workplaces.

More ambitious and more difficult are retrospective radon measurements that are needed for accurate exposure estimates for epidemiological studies. It is appreciated that STUK first intends to evaluate the feasibility of different methods. The Panel recommends that the laboratory works closely with STUK's Radiation Hygiene laboratory to assess and develop potentially useful methods for the measurement of ^{210}Pb and its decay products (for example in house glass and in the skull) for assessing historical doses. It will also be important to take advice from laboratories in other countries that have investigated these techniques.

Exposure of the population and the workers to the natural sources of radiation are investigated (NORMA). The study will primarily be based on literature and on measurements and inspections previously carried out by STUK, supplemented if necessary by a set of complementary measurements. This expertise by STUK is indispensable for Finland authorities.

The toxicity of uranium, natural or depleted, is discussed everywhere in the world by the media and we can observe considerable fear among populations. Uranium is present in many natural waters and the best answer is to follow up the populations chronically exposed to natural uranium in drinking water. STUK has developed a good program with the kidney toxicity study of uranium in drinking water (JURMU) and other radioisotopes (JUORAS). It could be a European coordinator for studying the radiotoxicity of natural radioisotopes in drinking water. STUK could collaborate with France and Germany, and some other European countries, comparing observations in human and animal experiments.

[4] Research projects of STUK 2000-2002, STUK A179, June 2000, p.

Publications

The laboratory mainly publishes reports for national authorities and for public information (25 in the 1995-1999 period). This is as a result of requests by the Finnish authorities, which considers this to be a first priority. Moreover the atlas of radon is on the STUK Internet site. The laboratory has also published in Finnish journals (5). Three theses have been presented during this period, and two students are still working at STUK. In addition, fifteen presentations have been given at international conferences and 12 papers published in international journals. The Panel appreciates the diversity of publications and is satisfied by the publication effort.

Conclusions

This group performs a central activity for STUK and the Finnish authorities. It clearly permits the Finnish public to have good and detailed information on natural radioactivity. By collaborating with the Radiation Hygiene laboratory and the epidemiology group of the Radiation Biology laboratory, this unit contributes to the excellence of STUK priority programs. The size of the Natural Radiation Laboratory and the number of scientists involved permit a good balance between research (55% of working hours according to the interviewed scientists) and service activities. The Panel considers this distribution appropriate for this laboratory.

In the area of work on radon measurements the balance between research and services must be established by STUK. Although this partition of work seems well established, no documentation supporting this seems to be available. The professional level of the laboratory is of a good standard and the future projects are of relevant to practical problems in Finland. In addition, this laboratory is a co-ordinator of international programs. STUK has to preserve the present expertise of the laboratory for the future to allow a more complete estimation of risks from natural exposure, i.e. indoor radon. The Panel sees no need for a change in structure to support the proposed future programme of work in this area.

Recommendations

- Clarification by the management of the amount of effort to be spent on research and on services related work would aid future planning of the programme.
- Work on assessing exposure to radon throughout Finland and the development of remediation techniques in conjunction with local authorities is a priority.
- The need to reduce high levels of radon exposure is an important public health issue and STUK should work with the media to give this a high profile.
- The laboratory should work closely with the Radiation Hygiene laboratory to develop methods for measurement of ^{210}Po and ^{210}Pb that will be used for assessing historical doses from radon exposure. Collaboration with other laboratories that have worked in this area is essential.
- International efforts to assess doses and risks to critical groups of fauna and flora should be supported with the aim of protecting the Finnish environment.

Radiation Hygiene

Studies of radiation hygiene, i.e. radionuclide content of the human body, have indicated the population groups receiving higher radiation doses via ingestion than the population in average. This applies especially for people in Northern Finland consuming large amounts of reindeer meat. Lichen is the major source of nutriment of reindeers and effectively accumulates radioactive elements deposited on it from air. The body contents of male reindeer herders increased from 5.5 kBq to 13 kBq in 1988 after the Chernobyl accident, mainly due to intakes of ^{137}Cs, but decreased to 4 kBq by 1997, when the last measurements on the group (followed since 1961) were made. The mean annual effective dose for the reindeer herders was about 0.4 mSv in 1988. The body contents of female members of reindeer herding families, and the corresponding doses, were about half of the values for the male reindeer herders due to the lower consumption of reindeer meat and shorter half-time of retention of ^{137}Cs in the body

Two other special groups have been investigated by STUK during the past few years; one consists of people in Padasjoki in Central Finland and the other in Viitasaari, also in Central Finland. Consumption of important levels of fresh water fish from small lakes and other wild natural products (mushrooms, berries etc.) in these municipalities, which received relatively high levels of fallout from the Chernobyl accident, has been identified as the reason for this increase. The results of studies on the population have shown that the body contents within a certain fallout region are closely related to the differences in the composition of the diet, and to the activity concentration of the foodstuffs.

Important lessons were learnt from the European EPORA project coordinated by STUK. Effects of industrial pollutants (nickel and copper) on the dynamics of radionuclides in soil indicate that chemical pollutants may considerably change the transfer coefficients between compartments of the environment.

Contamination studies of workers at nuclear power plants have indicated clearly the importance of workers paying close attention to their working habits and to safety instructions.

Personnel

The laboratory has 5 researchers, and 1 laboratory operator. 2 persons retired this year but were not yet replaced. A proactive succession planning is urgently needed.

Main comments

This activity is of great importance for STUK, the nuclear industry and Finland’s system of radiological protection. The laboratory has surveillance and research activities, associated with the provision of expert services. STUK has to be careful to avoid a loss of competence due to a lack of succession planning for scientists in this critical field. Some actions are long-term and may need "protection" from decision-makers. Many activities directly relate to public information and are of great priority for the credibility of the entire Finnish radiation protection system.

Progress report

The study on the ^{137}Cs body content and resulting internal radiation doses affecting the population is of great importance and originality, because few countries in the world have a program of continuous monitoring of the population for ^{137}Cs, both before and after the Chernobyl accident. Earlier plans of decision-makers were to stop monitoring after a decade due to a probable end of the contamination problems linked to Chernobyl. Several data sets clearly show, however, that this assumption is no more correct. This is a consequence of factors such as the mobility of cesium in the environment, uptake by foodstuffs such as mushrooms, and a continuing intake by the general public, which is still considerable. During the first decade after Chernobyl, the results of whole body counting showed a decrease of the body content with an effective half-life of about 700-1000 days. Today, we are observing a strong change. There are indications that this is with the apparent half-life increasing to about 10 years as a result of continuing intakes in the diet. At present, the most recent results indicate that in the long term there may be a component with an even longer half life of 30 years, the physical half life of ^{137}cesium).

STUK should continue with this unique monitoring opportunity over at during at least the next 10 years because this result is potentially important for decision-makers. It will be important in relation to the management of future emergencies. It has to be understood that the consequences of future nuclear accidents with releases of ^{137}Cs may last longer than expected at present. Such monitoring, which is also only partly performed in Sweden, should be supported, at least in part, by the European Union because of its high priority for the whole of European radiation protection community. The same comment holds for monitoring of radioactivity in air. STUK and other national authorities need to be made aware that these two fields of activity provide most useful information and take on their full importance only when performed over several decades.

The EPORA programme was, during the 1995-1999 period, the only one programme concerned with combining radionuclide contamination with metal pollution. Unfortunately, STUK's staff were too much involved with other activities for a full analysis of results from this original and important programme. Manpower is still needed to be found for preparing the work for publication in peer reviewed journals.

The laboratory assesses the internal contamination with radionuclides of nuclear power plant (NPP) workers for the benefit of NPP’s and Finland’s occupational hygiene. This activity is of great importance for the management of NPP’s and essential for the acceptance by workers and the public of the use of nuclear energy.

Radionuclides such as ^{131}I in sewage water and sludge originating from medical applications create a permanent dilemma between radiological risk and medical benefits from the use of radioactivity. The expertise of STUK is needed to generally inform the management of such risks.

The laboratory also conducts bioassay measurements to assist small industries. STUK is once more the only laboratory in Finland which can perform such activities at the quality level expected. This laboratory participates in international inter-comparisons, such as those organised by EURADOS and Procorad. These inter-comparisons are essentially needed for accreditations and are therefore a must, and have to be continued by STUK.

Recommendations

STUK has to clearly support the monitoring of ^{137}Cs content to the population as explained above.

STUK could study the dependence of the biological half-life of cesium with time since environmental deposition but has to select original points not yet described in the open literature, for example after the Goiania accident. The specific situation of Nordic food chains will emerge from dietary surveillance and radiological research on local foodstuff.

STUK participates in OMINEX, a new European project which compares the cost of protection for external and internal exposures, and their relative relevance. This participation is of importance for the monitoring of radiation workers as internal exposure assessment continues to be the least accurate element among the dosimetric systems, and the most expensive. To be accepted, the results will have to be well explained and understood by workers because, since many years, we have developed many sophisticated techniques for internal dose estimation and workers might not readily understand why we wish to reduce the emphasis.

For the public, this program mainly depends on perception, but it seems logical to develop improved and new techniques for determining natural radiation exposure in a country with the largest radon exposure in Europe. Unfortunately, Finland could today not expect European financial assistance, from which it has profited during the 5th PCRD, to support prospective research

Publications

The laboratory has a wealth of research results that have not yet been published.

However, a considerable effort has been used into publishing results in the proceedings of workshops (22). In addition, 8 articles have been published in international journals, although this is not yet considered sufficient in relation to the amount of work that has been carried out. The work for two research theses was performed in the laboratory. The laboratory has also published 8 reports and 2 papers in Finnish journals. This not fully satisfactory situation is explained by the relatively low and insufficient number of scientists involved, who have a large number of surveillance and monitoring activities as their primary task.

Conclusion

The group performs a central activity for STUK and the Finnish radiological protection system. STUK's managers need to demonstrate support for the programme. Without the replacement of key staff as they retire, there will be a progressive decline of activity in this area, which will affect the ability of STUK to monitor levels of activity in the body and to give sound advice. Long term monitoring is needed for a realistic assessment of exposure and complete management of accidental situations.

This group needs to actively participate in international conferences and symposiums to be able to present the results of its highly original research results in full. There is a potential to become more involved in the work of international groups such as those of ICRP Task Groups. This will be for the benefit of STUK.

Recommendations

- The laboratories core activities, which are of great importance for STUK, Finland's nuclear industry and the radiation protection system, are maintained at least at the present level.
- STUK should continue monitoring the ^{137}Cs body content of the population over at least the next 10 years. The situation in Finland is unique and the information to be gained is potentially important for decision-makers in the event of future nuclear accidents.
- This work should be complemented by studies to examine sources of activity in the national diet.
- Emphasis should be placed on publishing information from the unique data sets held by STUK.
- Efforts to provide information to the public are to be kept at a high level to maintain the credibility of STUK as an authoritative and impartial body giving advice on radiation protection issues in Finland.

Nuclear Power Plant Environment

Environmental monitoring of radioactive substances in the environs of Finnish nuclear power plants is the main function of the NPP Environmental Laboratory. The laboratory fully charges these services to the power plant operators. The laboratory also has the responsibility for developing the monitoring programs for the power plants and for the Quality Assurance of sampling methods used by STUK's laboratories.

The radiological impact of Finnish power plants on the populations living in their vicinity is insignificant. The main source of exposure for populations remains the marine environment. A bioindicator, Fucus vesiculosus (seaweed), has been used with success in joint Nordic studies. But the most notable impact of NPP is in winter, through the thermal effect of cooling water release during freezing conditions. The littoral vegetation has become more eutrophic and phytoplankton primary production has increased.

The Baltic Sea is mainly contaminated by fallout from the Chernobyl accident. The total input of ^{137}Cs from Chernobyl has been estimated at 4700 TBq. Until 1996, the cumulative decay-corrected contribution of the local nuclear facilities was only 1.7 TBq for ^{137}Cs. During 1950-1996, the maximum annual dose to individuals from any critical group in the Baltic Sea area was estimated at 0.2 mSv y^{-1}. However the residence time of ^{137}Cs in the Baltic Sea is relatively large ($T_{1/2}$ about 25 years) as compared to the North Sea or British Channel.

The laboratory has been involved in two marine radioecology projects and more especially in studies of interactions between sediments and radionuclides. The results showed that the sedimentation rate in the Baltic Sea varies over a very broad range. The laboratory has also recommended more than one method to evaluate sedimentation rate, because of unstable environmental conditions. The total inventory of ^{137}Cs in the seabed was estimated at 2.14 PBq in 1996. This contamination will be the main source term of water contamination when Chernobyl input will decrease.

After the Thule accident in N.W. Greenland, surveys carried out in 1968, 1970, 1974, 1979, 1984 and 1991 showed that the pollution remaining in the seabed as a consequence of the accident, amounts to approximately 1.4 TBq of ^{239,240} Pu (0.5 kg), 0.025 TBq of ^{238}Pu, 4.6 TBq of ^{241}Pu and 0.07 TBq of ^{241}Am. The last expedition in 1997 showed little migration of plutonium at this site.

In spite of the dominating services related work, the laboratory has also developed a good and effective method for separating strontium from environmental samples. It is based on extraction chromatography using a special reagent. Two versions of the method were developed, one for routine analysis and another for emergency measurements, which shortens the normal analysis time needed. The laboratory has also developed a new method for ^{241}Pu analysis in environmental samples. This technique based on liquid scintillation has been published in an international journal. The detection limit is very good, i.e. 0.007 Bq per sample. Lastly, the laboratory has developed a new method for analysing ^{99}Tc in environmental samples based on extraction chromatography using also a special reagent; the detection limit is 0.03 Bq per sample.

The behaviour of plutonium has been studied in different research programmes in the laboratory. It has been shown, for example, that ^{241}Pu was clearly present in the Chernobyl fallout in Finland and Baltic Sea. The ratio of $^{241}Pu/^{239,240}Pu$ isotopes was about 70 to 1.

Personnel

4 scientists, 1 student and 4 laboratory operators or technicians work in the group.

Main comments

This group is largely involved in customer services to NPP owners, which ask this laboratory to provide reports 4 times a year.

- Scientific work of a research nature is difficult to reconcile with the service function but the quality and dedication of staff has allowed the development of considerable expertise in the transfer of radionuclides in sediments.

- This laboratory collaborates with the food chain laboratory but nevertheless also performs radionuclide measurements itself. Further thought and justification needs to be given to this at first sight apparently unnecessary duplication of activities and equipment.

Progress Report[5]

1. A special expertise of STUK in the Thule monitoring programme is not given in the report. The Panel suggests that STUK enhances its contribution from mainly furnishing analytical data for Danish use to a partnership of equal standing for the assessment phase. During discussion, scientists explained that the Pu distribution at the monitoring site is largely heterogeneous and that the contamination doesn't move from the impact point. These results in an open field are not well known to experts of waste management which have to predict transfer of radionuclides in less open systems, i.e. without water. The Thule results need to be made available for use in other fields of radiological protection or waste management.

2. The participation in the Baltic Sea programs is professionally rewarding and of importance for NPP operators and Finland.

3. In spite of limited opportunities for research, the Panel notes that the laboratory has developed a radiochemical method for determining ^{241}Pu in environmental samples.

Future projects[6]

- With 4 scientists, this laboratory has developed 9 projects of which 5 are new. These are the following:

- participation in FASSET

- forest Ecosystem in the environment of NPP

- coastal ecosystem in the environment of NPP

- optimising the size of environmental samples. This point is more important for this laboratory than for others

- radiochemical determination of several nuclides in one sample for emergency response

the development of these projects has involved a substantial amount of original work and this clearly demonstrates the creativity of the staff in this laboratory.

Publications

The staff of the laboratory has published many papers in the open literature (9), participated in conferences or symposia (10), and prepared domestic reports (4). This is a good publication

[5] Research activities of STUK 1995-1999, STUK A 180, August 2000, p 75-86
[6] Research projects of STUK 2000-2002, STUK A179, June 2000, p.

record. A research thesis was carried out in the laboratory; the former student is now working in the laboratory.

Recommendations

- After comparing the objectives and manpower of the Food Chain Laboratory with those in the NPP laboratory, the Panel suggests that some restructuring within STUK should be considered. Whether merging the two laboratories will improve STUK's programme would need careful scrutiny but concentrating radiological analyses in one laboratory probably is more efficient. It seems to the Panel that the NPP laboratory, which appears to be the most creative, may provide the focal point for such a development.
- STUK should aim to publish data on the Baltic Sea biota obtained in the EU sponsored project.
- STUK needs to make it clear to the operators of NPP's that the quality of work achieved in this laboratory can be only maintained if they fund a part of related research activities. This could take the form of capacity building by support for research students.
- The expertise developed by staff in the laboratory in relation to the movement of radionuclides in sediments needs to be exploited further to achieve a higher profile.

Ecology and Food Chains

The Nordic countries have participated together in research programs designed to estimate man's exposure to radiation from radionuclides in plant and animals products of representative semi-natural ecosystems in Europe, more especially the Nordic ecosystems. Results are compared with other countries with very different ecosystems such as Germany and Italy. Finland in this European project (LANDSCAPE) quantified the influence of forest management and the use of primary fertilization on radiocesium distribution, and assessed the use of fertilizers as a possible countermeasure. It showed that in general, the seasonal variation in radiocesium follows the pattern of potassium, but is not fully identical. Fertilizers can be an efficient countermeasure to reduce cesium uptake by plants. The availability of timber for the wood industry can be increased by long-term treatment. Such methods provide ways to retain the principles of sustainable forestry after environmental contamination, as the treatments do not drastically change the ecosystem.

With this experience acquired during previous national and Nordic projects and during the LANDSCAPE project, STUK has developed with IPSN (France) a sub-module for the RODOS system. This module can predict internal doses received through wild foodstuffs, and external exposure from radionuclides distributed in the forest for periods between one day and 50 years after deposition. The program calculates deposition to forests from data on air concentrations of radionuclides and activity deposited in rain, provided by the atmospheric dispersion module of RODOS. STUK has also participated in the development and validation of a regional lake model for RODOS to predict the transfer of deposited radionuclides to fish. The model describes water catchment, behaviour of radionuclides in the lake and their uptake by fish. It is being implemented as a part of the RODOS system.

The information that has been obtained on the long-term distribution of radionuclides in lakes clearly shows that certain fishing areas in Finland are more vulnerable to radioactive contamination than others. Cesium moves quickly from the water phase to bottom sediments, while most strontium remains in the water phase and moves with the water flow. After entering in the sediment, ^{90}Sr is more mobile than ^{137}Cs. But, on the level of the critical product, ^{137}Cs transfers into the edible tissue of fish, while ^{90}Sr enters the bone tissue.

When deposited in soil, ^{137}Cs is removed by run-off to the Baltic sea, only six times more than ^{90}Sr because strontium remains in the water phase, while cesium is attached to sediments. Until now, only 1-3% of the deposited ^{137}Cs were removed by rivers to the Baltic Sea. River discharges of fission products from Finland to the Baltic Sea were significantly higher than releases from nuclear power plants and research reactors.

When the mobility of fallout derived from weapons tests and Chernobyl is compared it was shown that there was no significant difference in the temporal changes in ^{137}Cs mobility from these two sources during the years following deposition. This could be explained by a quite similar speciation of the fallout, which would exclude a significant contribution from fuel particle deposition in Finland

Personnel

The work force consists of 6 scientists, 2 assistant researchers and 3 laboratory operators.

Main comments:

There are too many projects, and radionuclide measurements are not centralised within STUK although the methodology and QA is generally common for the different laboratories.

The specific methods used for many radionuclide measurements involve difficult radio-analytical analyses such as those for ^{239}Pu, ^{210}Po, ^{90}Sr which contain radiochemical separation steps. It seems difficult for the staff in the laboratory to find time to develop new methodologies, although this may be desirable. For example the ^{14}C detection level seems just sufficient for monitoring but not so to provide information for further study.

Progress Report

1. The participation in the LANDSCAPE project was well targeted. The results indicate the benefits of the use of fertilisation for the restoration of contaminated forests in a severe fallout situation. This study has permitted STUK to become a forest ecosystem specialist. Unfortunately, STUK does not seem to have much contact with the modelling activities conducted by SSI. In this area, STUK needs to develop and publish advice on the management of contaminated forests as soon as possible if it wishes to keep its scientific leadership in this field. The development of a sub-module for RODOS in this field has confirmed the leading role of STUK in this area.

2. STUK has developed a regional lake model for RODOS. This model should be published independently in a peer-reviewed journal. 3. Radionuclide distribution and transfer in the environment has been followed and validated by many experiments and measurements. This permits STUK to positively participate in international groups such as VAMP. Some parts of the programme are not very original, but do reinforce present knowledge, for example the importance of forest products in dose assessment.

4. Collaboration in the preparation of an international publication has clearly shown that the rates of decline in ^{137}Cs activity concentration 10 years after the Chernobyl accident approach the physical half- life of ^{137}Cs. These results are a major research finding for decision-makers and public information.

Future Projects[7]

Environmental impact of radiation: During the last years it has been widely recognised that protection of man is not sufficient in all cases and that other organisms must be protected against harmful effects of radiation. The principles of the International Commission for Radiological Protection (ICRP) applied until now are based on the assumption that protection of man will be sufficient to protect the environment. This may not necessarily be the case. The nuclear energy legislation of several countries, including Finland, states that the protection of the environment must be properly considered. However, neither internationally accepted criteria, nor a national framework for radiation protection of the environment in Finland exist so far. It is noted that the International Commission on Radiological Protection has established a Task Group under Lars Eric-Holm (SSI, Sweden) to examine protection of the environment.

To create the appropriate criteria, exposure pathways of various organisms in various environments, radiation doses to the organisms and the impact of any radiation doses need to be studied and understood. Suitable indicator species must be selected as reference organisms and generic models for the estimation of radiation doses developed. Based on these data the level of radiation protection necessary for the protection of the environment should be determined. The criteria must be internationally accepted. The criteria will be needed for national decisions and actions, such as on nuclear waste disposal.

STUK with its many radioecological activities is well placed to play an important role in this emerging field of radiation protection. A close international interaction in the development of protection philosophies for the direct protection of the environment from ionising radiation is suggested. Together with other Nordic countries, Finland might contribute specifically to the assessment of doses and potential effects to sub-arctic food webs.

FASSET: Clarification of this new project on the objectives is needed. It seems to the Panel that the approach is yet too confusing, the deterministic effects which can follow an accident (Chernobyl) or bad practices at a nuclear site (e.g.Techa River) do not directly relate to the question whether plants and animals are sufficiently protected when man is protected from for planned practices as described by the Publication 60 of ICRP. These two extreme situations are accidental situation not regulated by ICRP recommendations. STUK, in its report 2000-2002, seems to misinterpret the ICRP concept.

However, STUK should participate in the reviewing the literature on deterministic effects of radiation and in the challenge of developing methods for ensuring protection of the environment. It may be appropriate for a professional from STUK to participate as corresponding member in the work of the new ICRP Task Group.

2. Work on forest ecology and radioactivity of timber has to be finished as soon as possible. The radiological consequences of the use of wood energy is curiously contriving.

3. Assessment work on plutonium in forests is a programme that is performed to alleviate public fears, without any significant added value for dose assessment and public health. However, plutonium remaining a radioactive element that causes public concern, an institute like STUK cannot avoid this type of program. STUK has to be careful in retaining a proper level of scientific research when providing information for the public and trying to build effective communication on emotional topics.

[7] Research projects of STUK 2000-2002, STUK A179, June 2000, p.38

Publications

There are many publications with STUK staff as co-authors but among 5 scientists, only two have published reports or participated in workshops as a first author (7 papers) and as second author. The group has prepared, a total of 12 reports, 16 conferences proceedings, as well as 8 publications in international journals and 2 in Finnish journals. The group participates in the training and work of professional colleagues in Europe.

Conclusions

The Panel considers that the group develops too many projects and does not put sufficient emphasis on publication of its work. The Panel considers that this laboratory carries out good work in EU projects and that its efforts are appreciated by its collaborators abroad. However, it seems too often reduced to a role as producer of results. This could be a result of Finland's recent arrival in the European Union (1995). In the future, STUK has to aim to take a more selective position.

The laboratory is too small to perform radionuclide analyses on its own. This point needs discussion inside STUK. In recent years, STUK has developed original expertise, as in modelling like the forest ecosystem. The Panel recommends capitalising on this advantage for the benefit of STUK and of European knowledge. STUK needs to take a more proactive role with this expertise inside the FASSETT program and should not continue to collaborate only as a mere provider of results. STUK is encouraged to join new networks, (such as those developing the use of mass spectrometry and other new techniques, for enhancing radioactivity measurements in the environment.

Recommendations

- The number of projects carried out by the laboratory should be reviewed, prioritised and then reduced to achieve a well targeted programme, Effort should go into the proper dissemination of the results in the scientific literature;
- Radionuclide analysis services should be shared with other laboratories inside STUK;
- The laboratories strengths, such as in studies of forest ecosystems should be further developed as a contribution to the global radiation research community;
- It may be appropriate for a STUK member to participate as corresponding member in the work of the new ICRP Task Group on the environment that is chaired by L.E. Holm.

Airborne Radioactivity

In case of an imminent or recent accident the first important parameter is the transfer of contamination. All major institutes in Europe have developed codes for post accident analysis. STUK participates in the Finnish crisis management centre with the Finnish Meteorological Institute and the Technical Research Centre of Finland. The crisis centre integrates all the models developed but does not so far use RODOS, which remains an experimental project in development.

The laboratory operates a nation-wide network of external dose rate monitoring stations. The alarm limit for stations is set at 0.4 $\mu Gy\ h^{-1}$, which corresponds to a radionuclide concentration of approximately 100-1000 $Bq\ m^{-3}$, depending on the nuclide. STUK also operates a network of 8 aerosol sampling stations; three of the stations are equipped with a real time radiation monitoring and alarm system. The system developed by STUK for its headquarters is automatic, modern and very efficient. A station on the centre's roof automatically reports the monitoring results on the STUK web site. There is the potential here for posting incorrect or non-validated information.

Radioactive particles, which may be released in a nuclear accident, are of importance radiologically and "hot particles" have sometimes been described as a new risk not previously studied. The airborne radioactivity laboratory devotes a considerable effort to the elucidation of potential exposures to, and lung and skin doses from such particles. Such assessments have to be validated in terms of probabilities, but only limited models exist for describing the atmospheric transfer and pulmonary tract deposition and clearance of large particles. A risk following skin deposition also exists in the vicinity of the accident, as confirmed with Chernobyl victims, but substantial information is available on the effects of hot particles on the skin. The laboratory should first study the probability of encountering a large numbers of such particles in the far field. However, the Panel notes that as in the case of plutonium, public perception and ensuing pressures may cause a need to study speciation and behaviour of "hot particles".

Personnel

This group has shown some growth during the last 5 years. At present, it consists of 6 scientists, 2 inspectors, 1 system analyst and 1 research assistant.

Main comments

- Airborne radioactivity measurement is a necessary core activity for STUK

- In comparison with other countries, the laboratory's Radiation Monitoring Network seems very dense but it has established a good scientific reputation and is important for addressing public concerns and providing advice to decision makers

- The threat of 'hot large particles' transfer to man seems to be overestimated as a public health problem.

Progress report[8]

1. The development of tools for emergency preparedness and the estimation of short-term consequences in case of a nuclear accident seem well developed for the benefit of the STUK crisis centre. The staff in the laboratory is aware of the present limitations of the RODOS system and this has allowed STUK to develop its own emergency response and expertise, not directly linked to RODOS.

2. The automatic system for radioactivity monitoring is well developed and operating successfully.

3. The potential impact of large radioactive particles in a nuclear accident seems to be overestimated. Today, we have limited knowledge and no models for the description of large particles and prediction of their behaviour in case of a nuclear accident. The suggestion of considerable radiation hazards following the discovery of particles larger than 20 μm seems illogical because these particles sediment quickly after release, and the probability to reach sites more distant than 100 km is very low and radiologically not significant. In the case of an accident, many particles will have a small size and the rounded value that ICRP has chosen of 1 μm as default parameter for inhalation by members of the public seems reasonable. The lesson from Chernobyl is that the exclusion zone contains the major part of large fuel

[8] Research activities of STUK 1995-1999, STUK A 180, August 2000, p 103-116

particles. The risk assessment for skin exposures from particles again does not seem to be realistic.

Future Projects[9]

The proposed radiation surveillance by an unmanned aerial vehicle (UAV) could be of value if the necessary needs for information cannot be covered by the Baltic States and Russia. However, STUK should justify in more detail where and how it will use the UAV. If a radioactivity increase is observed over Finland, the use of real-time powerful atmospheric transfer codes should be sufficient for recommendations to be made for decision makers in many cases. It is most important that effective lines of communication with other countries are maintained so that information about any radiation accidents is quickly shared between countries allowing effective decisions to be made. On the other hand, direct measurements might provide advantages on the level of public perception; such considerations are largely outside the realm of the Panel. It has also to be stated that once the decision for aerial surveillance by plane has been taken, UAV's have considerable advantage over manned planes, both financially and for potential radiation exposure of personnel.

Publications

The list of publications is of good quality. During the 1995-1999 period, 8 papers were published in international journals, there were 11 contributions to conferences and symposia, and 14 laboratory reports were published.

Conclusions

This laboratory also illustrates potential benefits from the aggregation of laboratory activities into a critical mass. The number of scientists is higher than in other laboratories. Even when participation in the crisis centre is taken into account, it would appear that the publication record is rather low.

The Panel considers the problem of exposure to large sized particles from accidental releases to be of minor radiological importance. However, it is recognised that there is public concern that needs to be addressed. The UAV project seems very expensive and has to be weighted against the benefits to be gained and the needs of other activities of STUK.

Recommendations

- The proposed scheme for radiation surveillance by an unmanned aerial vehicle (UAV) could be of value if the necessary information cannot be obtained from Baltic States and Russia. However the scheme is expensive and STUK should justify in more detail where and how it will use the UAV.
- Effective lines of communication with other countries should be maintained so that information about any radiation accidents is quickly shared between countries allowing effective decisions to be made.
- Radionuclide analytical services should be shared with other laboratories in STUK.
- The relative importance of doses and risks from hot particles and other airborne particulate radioactivity should be evaluated and priorities for research set accordingly.

[9] Research activities of STUK1995-1999, STUK A180, August 2000, p.115-116

Regional Laboratory in Northern Finland

The Arctic is characterised by a harsh climate with extreme variations in light and temperature, shorts summers, extensive snow and ice cover in winter and large areas of permafrost. The plants and animals of the Arctic have adapted to these conditions, but sometimes they are more sensitive to human activities. Unfortunately the arctic was a site for atmospheric nuclear weapons tests and is witness to environmental pollution from, chemicals, radioactive materials, etc. The location of the Russian nuclear fleet reinforces the anxiety in relation to this territory, especially of Nordic populations, but also of European and world-wide populations.

Among populations, the Laplanders are very sensitive to Arctic contamination. After a higher than average contamination by nuclear weapons tests, Lapps were also contaminated by Chernobyl fallout, although this time less than in Southern Finland. STUK has an established programme related to the exposure of the 200,000 inhabitants of North Finland, the largest population of Lapps in Nordic countries, and especially of the 4,000 Lapp (Sami) reindeer herders. Living conditions are very difficult.

The STUK laboratory is involved in a well-developed scientific programme network. It has studied the most important arctic food chain, lichen-reindeer-man and regularly monitors other elements in the food chain.

Today there are particular concerns about the Russian nuclear fleet, and the recent accident of the Kursk submarine has highlighted this, even if the Arctic sea is less contaminated than the Irish or Baltic Sea from civilian activities. The STUK Nordic laboratory is substantially involved in the monitoring of this critical area.

The Nordic countries have for some time been concerned with studies into the problem of sensitivity of arctic environments. The STUK Arctic laboratory has been an efficient partner of all countries in the AMAP project, then ARMARA and ARTICMAR. Mushrooms, salmons and other species have been continuously monitored and the information has been included in a databank. This is available for use by other Nordic countries.

The Nordic laboratory in Rovaniemi accumulates data for the benefit of all scientific communities interested in sensitive ecosystem, for example the Arctic Sea.

Personnel

The staff consist of 1 researcher, 1 laboratory engineer, 2 temporary assistant researcher and 3 operators.

Main Comments

This laboratory is the shop window of STUK's work in area of the region of the Polar circle. The head of the laboratory is the first contact for the local population, media and authorities. It seems to be the largest laboratory of all Scandinavian countries in the Polar Circle area. This laboratory maintains a good relationship with Russia which is to the benefit of Finland and the global radiation protections community.

Progress report[10]

All activities described in the 1995-1999 report are important for providing radiological protection advice to a population first exposed to significant levels of fallout from nuclear

[10] Research activities of STUK 1995-1999, STUK A 180, August 2000, p 117-123

weapons testing and, then to Chernobyl fallout. Today this laboratory contributes to the provision of information concerning the Russian nuclear fleet.

The Panel considers that STUK and Finland do not obtain optimal benefits from this activity, because Finland's effort is pooled in the Nordic effort. Additionally, the work of STUK has insufficient manpower to effectively exploit the results obtained by the laboratory. As in the similar case of the Thule plutonium problem, the laboratory is not in a strong position scientifically to develop a complete understanding of transfer mechanisms and to develop an independent compilation of the work.

Future projects[11]

This laboratory participates in FASSET, ARCTICMAR, AMAP and many other projects. Its participation is necessary for the progress of all these projects for the specific problem of arctic regions.

Publications

The Panel considered that the publication record of the Head of the laboratory was impressive. Co-authorship of 3 papers in international journals, 7 in conference proceedings and 3 laboratory reports is noted. In addition, the laboratory head was a first author in 1 international journal article and in 9 conference proceedings) yet, the laboratory conditions are mainly dominated by surveillance programmes. Sampling in Russian territories is both difficult and time consuming.

Comments

This laboratory is unique, in a good position for new studies in the arctic regions and for the surveillance of the Russian nuclear fleet. It seems to the Panel that Finland has not yet fully exploited the political importance in Europe of supporting such a laboratory when the media and public opinion are excessively anxious about the radiological risks from the nuclear activities and legacies of the former Soviet Union. Finland, supporting for this STUK laboratory, should strengthen these unique activities, for example by adding one more scientist to this laboratory. This may be possible by internal reorganisation and distribution succession planning needed for the next years.

Recommendations

- Given the uniqueness of the laboratory and an international need for radiological data in the context of arctic contamination, the staffing of the laboratory should be strengthened.
- Consideration should be given to seeking International funding for activities concerning the Kola peninsula and the radiological legacy of the former Soviet Union.

Medical Radiation

Medical use is the largest source of man-made radiation exposure. Most of this exposure comes from the use of X-rays in diagnostic procedures. The European Medical Exposure Directive (MED) requires many new functions to be developed, specifically the establishment of reference doses for various procedures, quality assurance, patient dose measurements, staff education and training, and clinical audits. This demands new approaches and techniques to be developed by the laboratory. During the next few years, priority areas for research are

[11] Research projects of STUK 2000-2002, STUK A179, June 2000, p.

optimisation of X-ray examination techniques, assessment of the performance of new imaging techniques, as well as determination of patient dose for various examinations and radiation risk analysis. Special emphasis will be placed on examinations requiring high patient doses (CT, fluoroscopic procedures) and those involving the most radiosensitive patients (paediatric patients).

Personnel

There are 5 members of staff. Most of the group were recruited in the mid 1970s and now have considerable experience of working in medical dosimetry. Consideration may need to be given to succession planning in the next few years if the skills are to be maintained long term in the unit.

Research Programme

An extensive series of studies and investigations are being carried out. Brief comments on each are given below.

Relationship between objective and visual image quality in fluoroscopy

This study has aimed to develop methods for quantifying improvements in fluoroscopic image quality by assessing the signal to noise ratio (SNR) of an “ideal” observer. Comparisons have also been made of the efficiency of viewing static and dynamic images. It has been demonstrated that measurements of SNR^2 can provide a basis for assessing image quality. It is not clear whether this approach has been used in clinical medicine but if not then validation of this approach should be actively considered as fluoroscopic examinations can give substantial patient doses and reductions in exposure are highly desirable.

Optimisation of imaging techniques in paediatric fluoroscopic examinations.

This has been a significant collaborative program of work that has been important in identifying methods for reducing doses in paediatric examinations without reducing image quality. Initial modelling studies indicated that about a 35% reduction in exposure could be obtained but a comparison between doses received in Finland and those in other European countries suggested much greater reductions might be achieved. Although not all the predicted reduction could be obtained, because of limitations in equipment, dose rates could be reduced by between 30 and 80%. This is a very worthwhile saving. As children are the most sensitive group in the population dissemination of this information and the provision of advice on more appropriate fluoroscopy equipment would seem to be desirable.

Annual frequencies of x-ray examinations for adult and paediatric patients

This EC sponsored study had provided valuable information about medical exposures of the Finish population. To provide improved information on the contribution of x-rays to the collective dose for the population information is also needed on patient doses per examination. So far this information is not available from Finland in any comprehensive way, although exposures can be estimated from questionnaires (carried out by STUK) and from data available from other Nordic countries. It is important in the context of the European MED to obtain more information on exposures in Finland.

Patient dose measurements for paediatric radiography, fluoroscopic and CT examinations

This project is providing data that will help considerably in setting reference doses as required under the European MED. Doses from radiographic examinations were based upon measurements of dose-area product (DAP) which is becoming a standard method for dose assessment via calculations of entrance surface dose (ESD).

Nordic patient reference doses in adult x-ray examinations

This is another project concerned with assessing exposures from radiographic examinations and is essential in providing data needed for setting reference doses.

PCXMC – A PC-based Monte Carlo program for calculating patient doses in x-ray examinations

This computer program is valuable in allowing the extrapolation of patient doses from measurable quantities (ESD and DAP). It is now being extended to include exposures in complex fields.

Radiation risk assessment for patients of various ages

This software package uses base line cancer rates of the Finnish population together with age dependent relative risk models to calculate measures of radiation detriment. The risk models come principally from BEIR V (1990) and therefore could be usefully updated, although it might be expected that there would not be substantial changes to presently calculated values of radiation detriment. This is a valuable software program, which could have a number of applications. It has been used to estimate radiation risks to patients from medical examinations and the consequences of Chernobyl fallout. It also has the potential for use in training course to demonstrate the consequences of medical exposure, for example how the risks change with age. It could also be used in litigation, if cases resulting from suspected overexposures to radiation should come to court.

Calculation of shielding in x-ray department

This program would appear to be a valuable tool for use in the design of shielding for x-ray facilities.

Development of boron neutron capture therapy (BNCT) dosimetry with TL dosimeters

Considerable effort has gone into developing dosimetry for BNCT in recent years. There has also been a substantial effort in a number of other countries. It seems likely that little more can now be learned. Unless there is a clear clinical need for some further work then this program could be brought to a close in the coming year.

Research plans for the next five years:

A number of areas of work that have been pursued over recent years are to be continued. These are listed below. The general comments above still apply.

- Development of a method to follow up x-ray examination frequencies and patient doses.
- Further development and application of the PCXMC patient dose calculation program.
- Computer program for radiation risk assessment.
- Performance measurements of x-ray diagnostic units.
- Objective methods for measuring the image quality of radiographs.
- The relationship between measured and visual image quality.

In addition a new project is proposed:

- Measures for optimising radiological information and dose in digital imaging and interventional radiology (DIMOND III)

This study seems to be directly relevant to the implementation of the European MED in Finland.

Publications

The group has published 20 articles in leading peer-reviewed journals and two in Finnish journals. In addition, 8 proceeding articles or conference papers, and 10 reports were produced. This amounts to an excellent publishing profile.

General Conclusions

The European Medical Exposure Directive provides the basis for much of the work now being carried out within the laboratory. The adoption of this Directive is a significant development in Europe and will be important in improving the care of patients. Although Finland was one of the first Member States which implemented this Directive into national legislation, it would appear that Finland has been relatively unprepared for the implementing this Directive into daily clinical practice, although much is now being done. A key feature of the Directive is the need to establish reference doses for diagnostic procedures. These are doses that can be achieved with current technology and will give the necessary diagnostic information without over-exposing the patient. Little direct and experimental information seems to have been available on doses from medical procedures in Finland and this is now being obtained from questionnaires, from measurements and from information available through Nordic countries collaboration. Countrywide statistical questionnaires on patient and population doses of diagnostic radiological procedures have been carried out. The information from STUK has been used in the development of a draft Code of Practice on References Doses. The paucity of information on radiation doses in diagnostic radiology appears to be partly due to the lack of hospital physicists in this area and a general lack of professional interest in the doses received. This highlights the need for appreciable input from STUK in this area, particularly in dose assessment and in training of medical professionals.

Apart from the development of reference doses the implementation of the European MED will require a number of issues to be developed. These include the improvement of methods for assessing doses and quality assurance for exposures as well as the development of a clinical audit scheme. Training is also a key feature of the implementation of the Directive.

The Medical Radiation Group has a number of other issues for which they are responsible and some thought will need to be given as to how the work should be prioritised. The following recommendations are made.

Recommendations

- The work in support of the European Medical Exposure Directive should be given priority. The main emphasis is on the assessment of reference doses and a consultation document has already been prepared. Consideration may need to be given to freeing up resources to allow this work to be taken forward.
- There is a lack of specific information on doses received in Finland and efforts should be made to redress this situation.
- Effort is needed on the development of monitoring techniques, using for example TLD and dose area product meters, as well as of QA procedures and training.
- Some areas of collaboration with other Nordic countries have already been developed such as in sharing information on doses from diagnostic radiology. It would be advantageous to

consider whether there could be effective collaboration in other areas with the aim of dividing responsibilities, for example in developing QA methods and in audit procedures.

- STUK should work to develop international contacts and enhance training at the national level to overcome the local lack of medical physicists in diagnostic radiology.
- Considerable effort has gone into boron neutron capture therapy. This could now be discontinued unless there remains a clear clinical requirement.
- Further development of the software programme for risk assessment could come from the epidemiology group. If the programme is to be developed further, it might be more appropriately placed in this group.

It is noted that tasks related to medical exposure are shared between two departments, Department for Radiation Practices and Regulations (STO) and Department of Research and Environmental Surveillance (TKO): the regulatory control and legislative preparation work including the implementation of EU directives belong to STO and the supporting research with development work concerning x-ray diagnostics belong to TKO.

Radiation Biology

The work of this Laboratory is mostly dedicated to research on the biological and health effects of ionising and non-ionising radiation, especially cancer. Its considerable size of 19 scientists allows active participation in international research activities. Of 15 on-going international projects, 9 are financed by the European Union. The publication record of the last few years in peer-reviewed journals shows a full integration into the international radiation biology and epidemiology community. In the apparent absence of academic structures in this area in Finland, STUK seems to be the only national institution with a comprehensive activity and in-depth professional knowledge in radiation biology and epidemiology.

The studies related to concerns about exposure to ionising radiation are:

- Minisatellite mutations and biodosimetry of the population around the Semipalatinsk nuclear test site (EU code: SEMIPALATINSK).
- Radiation-induced heritable mutations in humans.
- Pooled analysis of European case-control studies of radon and lung cancer (RADON EPIDEMIOLOGY).
- Cancer risk among nuclear workers (LOWDOSERISK).
- Cancer risk among airline personnel.
- Cancer among Saami people (Lapps).
- Kidney toxicity of uranium in drinking water (JURMU).
- Radioisotopes on drinking water and cancer risk (JUORAAS).
- Chernobyl fallout and adult leukaemia.
- Brain tumours and x-ray examinations.
- Radon and lung cancer: an analysis using additive generalised linear models (RALMA).

Further studies are also proposed for the period 2000-2002 in STUK-A180 although no further details are given. These are:

- Leukaemia incidence in the vicinity of nuclear facilities.
- Follow-up chromosomal aberration frequencies among accidentally exposed subjects.
- Cytogenic biomarkers and human cancer risk (Cancer Risk Biomarkers).
- Cancer incidence among Baltic Chernobyl clean-up workers.

For non-ionising radiation one study related to exposure to RF radiation is given in STUK-A179:

- Mobile phones and the risk of brain tumours (INTERPHONE).

Further studies are also proposed for the period 2000-2002 in STUK-A180 although no details are given. These are:

- Health risk assessment of wireless communications (LaVita).
- Risk evaluation of potential environmental hazards from low energy electromagnetic fields (EMFs) exposure using sensitive in vitro methods (REFLEX).

No studies seem to be planned on the health effects of UVR.

Radiation epidemiology

The main research issues in radiation epidemiology deal with effects of 1) low radiation doses on cancer risk, 2) internal exposures from radionuclides on cancer risk, 3) ionising radiation on diseases other than cancer, 4) effect of non-ionising radiation on cancer risk.

In the research programme, effects of low doses on cancer induction are addressed through participation in large international collaborative studies including currently on-going studies on nuclear workers and airline personnel. Research on effects of internal exposures includes studies on ingested radioisotopes from drinking water and diet (especially reindeer meat). Studies on effects of radiotherapy on cardiovascular and endocrine disease are being planned. Both international and national studies on health effects of radiofrequency magnetic fields from cellular phones are on-going.

Epidemiological studies thus relate to concerns about exposures to both ionising and non-ionising radiation. The studies are detailed in the review of research projects for 2000-2002 (STUK-A179) and are not repeated here.

In the time available for the review it was not possible to examine the extensive range of epidemiological studies being carried out in any detail. Rather an overview of the totality of the studies was given which provided the basis for some general comments by the Panel and specific recommendations.

General Comments

For the foreseeable future quantitative information on the health effects of exposure to ionising radiation must rely upon the results of epidemiological studies. Present evidence is that such studies can only provide information at doses above about 100-200 mGy (low LET) (UNSCEAR 2000). There continue to be concerns about health effects of lower dose exposures and at present these can only be obtained by extrapolation from the high dose studies using a dose and dose rate effectiveness factor (taken to be 2 by ICRP). In due course models based on an understanding of the mechanisms of radiation action may be able to provide improved information on the effects of low doses. However, this is not the case at present. In addition, where there are concerns among members of the public about possible health effects of ionising and non-ionising radiation, epidemiological studies can provide reassurance. Their limitations do, however, need to be recognised. Epidemiological studies must therefore make a major contribution to the work of any organisation giving advice on radiation protection and health effects. It is also essential that the advice is soundly based and demonstrates an understanding of the strengths and weaknesses of any studies.

For non-ionising radiation, there continue to be concerns about possible health effects of electromagnetic fields, and in particular at present those from base stations and mobile phones. There is little possibility of carrying out epidemiological studies related to exposure to base stations and public reassurance can only be given by making measurements of exposure at situations to which people have access and making comparison with exposure guidelines. This is the approach being followed by STUK. In relation to mobile phones, exposures are higher although it would be expected that they would still fall within exposure guidelines. Whilst present knowledge would suggest the induction of cancer as a result of exposure to RF radiation from mobile phones is most unlikely there have been concerns about a possible promotional effect. Again there is little good evidence that this may occur but there is little specific information on any risk arising from exposures to mobile phone frequencies. Consequently, there are grounds for carrying out an epidemiological study to examine whether RF radiation from mobile phones may affect the incidence of brain cancer.

No epidemiological studies are being carried out at present in relation to exposure to UVR yet such exposure is known to cause skin cancer. The use of sunbeds is widespread in Finland and techniques for measuring UVR exposure are available in the NIR laboratory. There may be the potential to carry out a significant study on skin cancer risk in sunbed users. Much will depend upon the extent of use of sunbeds in the country and the number of heavy users. During preparation of the report, the panel was informed in writing on future projects to study the relationship between clothing coverage and melanoma incidence, to follow temporal changes in melanoma incidence, and to assess the influence of skin type for different UV sources.

There are, therefore, good arguments for STUK to be actively involved in epidemiological studies. A particular advantage for any studies carried out in Finland is that national health registries and mortality data allow causes of death to be identified and good quality analyses to be carried out. However, a major limitation is that the population is small and any study will generally have very limited power for detecting any effects. The only solution to this dilemma is to carry out collaborative studies with organisations in other countries and this is the route that has been followed by STUK. Essentially all the major studies being carried out in the laboratory covering both ionising and non-ionising radiations are of a collaborative nature. These are either with partners from the EU, from North America or from the Baltic or Nordic countries. The Epidemiology Group has been successful in obtaining outside funding and this reflects the high quality of the work being carried out in the unit.

It is clear though that that the number of epidemiological studies in which STUK is involved is extensive. Many of these studies, whilst being competently carried out, cannot be expected to provide any quantitative information on risks. A number of other studies may not provide quantitative information with good precision in the near future but are important to be involved in, as they will increase confidence in present protection standards. Such studies include occupational studies of radiation workers, lung cancer risks in persons exposed to radon in homes, and brain cancer in users of mobile phones.

There is a need to internally review the span of studies being carried out as the total portfolio is likely to become increasingly difficult to fully support. The reasons for being involved in the various studies are in part scientific and in part because of public health concerns. In addition a number seem to have been undertaken because of a wish to collaborate with Baltic countries. Once such studies have started it is often difficult to bring them to a satisfactory conclusion and the tendency is to continue to support them. There is a strong argument for undertaking, in house in the first instance, a comprehensive review of all the epidemiological studies. They should aim to identify priorities for carrying out the work and establishing whether there are good reasons for their continuation. It should be possible as a result of this exercise to decide which studies to maintain and which to seek to discontinue on a defined time-scale.

Recommendations:

- The epidemiology programme being carried out by the Group is of high quality and it is important that such work continues to underpin the advice STUK gives on health effects of ionising and non-ionising radiations.
- Collaboration with other laboratories is essential and should be continued.
- All the epidemiological studies presently being carried out should be reviewed, to determine priorities and to identify those to be maintained long term and those that should be discontinued.
- Consideration should be given as to whether a study on the effect of sun bed use on skin cancer could be carried out.

Mechanisms of radiation-induced cancer

A mechanistic understanding of the complex genetic and epigenetic changes in single cells and tissues research on cancer and aging on the molecular, cellular and animal experimentation level is an endeavour involving tens of thousands of scientists at universities and large private and state controlled institutions. The primary damage set by ionising or non-ionising radiation is not that different to justify specialised research activities in the area of radiation biology per se. Therefore STUK should concentrate on niches and unique contributions on the national and international level. Biological indicators range from measures of exposures to measures of risk and finally disease. The former include primary and fixed DNA damage such as DNA lesions, chromosome aberrations and micronuclei, the latter involve activation of proto-oncogenes, over-expression of oncogenes, tumour suppressor gene function loss, induced genetic instability, loss of apoptosis functions, only to mention the better known. Here, the many advantages in the dosimetry of physical agents acting from external sources can be exploited to answer important questions in quantitative ways. In selection a small number of sustainable activities in STUK, the following aspects should be considered:

- Is there a direct link to the quantification of risk from ionising or non-ionising radiation?
- Does the activity help to increase the understanding of mechanisms in radiation-induced carcinogenesis in a way to improve counselling by STUK about risks from environmental and occupational risks in Finland, both at the level of professional organisations and the public and media? i.e. by increasing confidence in Finish protection standards.

- Are there areas of applied radiation biology or epidemiology where there are higher stakes for Finland than for other countries? Examples might be:
  - elevated skin cancer risks from higher prevalence of UV-sensitive skin types
  - potential risks from higher exposures to actinides in drinking water
  - radon and lung cancer risks
  - risks from sub-arctic ecosystems
  - exposures from wireless communication.

The main aim of the present research programme is to clarify the mechanisms of radiation-induced carcinogenesis. Understanding the critical molecular events in neoplastic transformation and tumour development after radiation exposure would provide opportunities for radiation protection at a new level. Knowledge of the relationship between early changes in gene expression has the potential to provide new tools in diagnosis, tumour classification, cancer prevention etc. Identification of critical factors such as events and pathways may enable identification of individuals with increased susceptibility to radiation and other agents. Understanding the mechanisms of cancer induction is especially important in the low dose range where epidemiological methods have severe limitations.

The proposed research programme focuses on:

- Gene expression analysis of genes related to cell cycle regulation or cell death pathways in childhood thyroid cancers that have occurred in Belarus following the Chernobyl accident.
- The significance of individual radiation sensitivity by mutational analysis of genes related to repair of DNA damage in secondary cancers after cancer radiotherapy.
- Gene expression and gene copy number in brain tumours in relation to radiofrequency magnetic fields and X-ray exposure.
- Identification of genes affecting induction of genomic instability.
- The role of genetic polymorphisms in the relationship between chromosomal aberrations and cancer risk.

These activities address in general one or several of the elements mentioned above as a prerequisite for a strong involvement of STUK’s radiobiology laboratory. The work on genomic instability is in a highly competitive area and, from time to time, the question will have to be asked whether STUK’s resources and the anticipated results will make a difference. STUK should focus especially on aspects leading from mechanistic knowledge on genomic instability in tumour biology to the potential role of this phenomenon in radiation protection. It will be important to continue to have close international interactions within the research programs of the European Union. Biological dosimetry and biological indicators of exposure and risk are more directly linked to radiation protection and may serve both control purposes and retrospective dose assessments for important epidemiological studies from unique human exposures to ionising radiation in the former Soviet Union. STUK’s laboratory having a good publication record in this area and being one of the international co-ordinators in this important field should further develop its stakes in biological indicators. Close links to human genetics activities in Finnish medical faculties - if existing on a larger scale – might be envisaged.

Biological effects of non-ionising radiation

With the rapid development of information technologies and wireless communication, exposure of the public to electromagnetic fields and especially radiofrequency (RF) radiation has increased considerably. Another public health concern is exposure to man-made and solar ultraviolet radiation (UVR).

The objectives of the work in the laboratory are to provide experimental data that will be used in the development of better radiation safety standards and the provision to the general public of information about the possible risks of exposure to non-ionising radiation. Irradiation set-ups and new methodological approaches for increased measurement accuracy are being developed. Dosimetry is an integral part of biological studies. These aim at determining the biophysical mechanisms of interaction between non-ionising radiation and living matter and the possible health risks associated with any exposure. The ultimate goal of the biophysical and biological experimentation is the identification of the possible cellular radiation targets and physiological end-points. This, in turn will allow determination of the possible health risks associated with exposure to UVR and RF radiation:

A series of studies are being carried in relation to exposures to both radiofrequency and ultraviolet radiation. The studies are reviewed briefly:

The effects of UVR on melanoma metastasis

Solar and solaria exposures are presently on the increase among the population with a consequential increase in exposure to UVR. STUK investigates the possibility that UVA radiation may stimulate melanoma cells to detach from the solid tumour mass and to metastasise. The study is being carried out by exposing mouse cell lines with different metastatic potential to UVA (a major part of the UV spectrum in solaria) and then examining their potential to metastasise in donor mice. Additionally it will give information whether tumour cells already shed from the primary malignancy potentiate their metastaic potential (extravasation) by UVA. In this context, the effect of UVR on the immune response, which is the subject of substantial debate at present, might be worth considering. There seems to be little good scientific evidence that it can cause changes in the immune response that can result in an increased risk of skin cancer. The lack of information partly results from the absence of a good animal model for UVR induced skin cancer. Such studies, whilst not strictly concerned with skin cancer, may help in understanding any effects of UVR on the immune response and could be valuable in understanding the role of changes in the immune response on cancer development, which is a perennial aspect also of radiation-induced carcinogenesis. Furthermore, by undertaking some work in this area it will ensure that staff in the laboratory participate in international meetings on studies related to the health effects of UVR and this should considerably help in informing the advice given by STUK.

Biological effects of exposure to RF radiation

Three experimental studies are being developed that will examine the effects of RF radiation on cellular systems. These cover:

- use of heat shock proteins of other biological markers as indicators of exposure
- effects on gene expression, protein production and cell cycle kinetics
- effects on signal transduction.

These studies are all based on cellular systems and rely on using modern molecular and cellular techniques to examine possible effects of RF radiation. Studies of this type have been carried out in a number of laboratories in recent years. There has been little evidence that in well controlled studies, and when levels of exposure are below those that can cause heating effects, any significant effects are produced. There was little time during the review to consider these studies in any detail. All three studies involve collaborators from a number of other institutes and will clearly involve substantial effort. Care must be taken to ensure that any research carried out in this area is well designed and carefully targeted. The ongoing studies should be kept under continuous review to ensure that results obtained are of value in underpinning the advice provided by STUK.

Recommendations:

- The radiobiological activities of STUK are unique and original in the Finnish context. This quality should also be maintained at the international level by concentrating on risks where the local exposure situation (radon, actinides in drinking water) or the average sensitivity of the population (UV-induced skin cancer) are high as compared to other countries.
- Highly competitive basic research on mechanisms of carcinogenesis should only be pursued at a level needed to maintain STUK's competence in applying evolving concepts in radiation protection and to maintain public confidence in STUK as a state of the art professional body.
- The strong activities in biological dosimetry and indicators should be maintained and further developed with international partners as a core activity of STUK.
- STUK should continue to carry out studies concerned with understanding health effects of exposure to ultraviolet radiation.
- Molecular and cellular studies designed to understand any effects of exposure to RF radiation should be kept under continuous review to ensure they are consistent with research priorities.

DEPARTMENT FOR RADIATION PRACTICES AND REGULATIONS

Radiation Metrology Laboratory

In view of the close interaction between this laboratory and the Medical Radiation laboratory, the rationale of many of the core activities was already discussed previously. Despite the considerable size of the group and an annual budget dedicated to research of about 500,000 Euro, only 1.5 man-years/year are defined to be research activities proper.

Personnel

The staff of the laboratory consists of 5 scientists and 2 technicians.

Expert services

The laboratory maintains national standards for ionising radiation quantities and provides calibration and testing services for equipment used in medicine and radiation protection. Regulatory control of radiation therapy through the preparation of guides, issuing of licenses, inspections and comparative measurements is another core activity of the group.

Aims of research

The research activities are closely defined by the needs of regulatory functions. The national standards maintained by the laboratory are mainly secondary standards, as the development of primary standards is not considered feasible because of the small resources available. The research on standards therefore concentrates on applying the secondary standards for calibrations, i.e. in the development of optimal calibration techniques. The research on radiotherapy dosimetry and quality control techniques aims at developing and supporting the methods used in inspections carried out by STUK at radiotherapy clinics, and more generally, at supporting the development of quality assurance and safe procedures in radiotherapy. The development of boron neutron capture therapy (BNCT) dosimetry using a twin ionisation chamber technique supplements efforts with TL dosimeters in the Medical Radiation laboratory. Quality assurance and control for well-established modalities such as high-energy electron beams and on new direct-absorbed doses with water calibration techniques for ^{60}Co gamma beams are deemed important for further enhancing the safety of radiation therapy in Finland.

Research plans for the next years

The projects to be carried out by the Radiation Metrology Laboratory are:

- Development of measurement techniques for quality audit in radiotherapy.
- Independent verification of dosimetry in BNCT (based on the application of microdosimetric techniques; as a partner in an EU-funded research project).
- Comparative measurements in radiotherapy (special emphasis on new radiotherapy techniques such as multi-leaf collimators, intensity modulated treatments, and stereo-tactic treatments).
- Quality Assurance of electronic portal imaging devices (EPID) (for use as a dosimetric tool).
- New calibration techniques for dosimeters in diagnostic radiology (choice of radiation

qualities, optimum calibration of dose area product meters, etc).

- Calibration techniques for brachytherapy sources.
- Use of direct-absorbed doses in water calibrations for radiotherapy dosimeters.
- Characteristics of new types of personal dosimeter.

Publications

More than 30 proceedings and reports were published in international publications by the group in the last five years. This indicates a good interaction with similar groups abroad. On the other hand, the group has not enough research activities to contribute original work through substantial input to peer-reviewed journals.

General Conclusions

Given the need for a further development of radiation therapy for cancer cure with minimal side effects, the planned activities of the laboratory are central to the mission of STUK. In view of the considerable effort gone into developing dosimetry for BNCT in recent years in Finland and a number of other countries, it is questionable that much more can now be improved in boron neutron capture therapy (BNCT) dosimetry. Unless there is a clear clinical – and hence regulatory - need for some further work, these activities could be redirected to areas with more impact on patient health.

Work on high-energy electron beams and on new direct-absorbed doses with water calibration techniques for ^{60}Co gamma beams directly benefit the safety and quality of radiation therapy in Finland and should be maintained at the present level.

Non-Ionising Radiation Laboratory

The laboratory carries out a number of functions related to exposures to electric and magnetic fields, ultraviolet radiation and lasers. These cover:

- regulatory functions under radiation protection legislation
- research and technical development
- development of radiation-protection standards
- provision of information to the media and public
- provision of technical services.

Personnel

There are 8 members of staff in the Laboratory, which has a good age structure.

Regulatory functions

Regulatory responsibilities account for about 15% of the work in this Laboratory. The question was raised during discussion as to whether regulatory and research responsibilities should be separated but there seems to be no necessity for this at present. The Laboratory has a responsibility to give guidance when any new NIR guidelines are issued, as from the International Commission on Non-Ionising Radiation Protection (ICNIRP). The new (1998) ICNIRP guidelines are being implemented in Finland. There is clear merit in the Group being involved in the development of NIR standards internationally, through for example the Head of the Group's membership of an ICNIRP Standing Committee, as any new guidelines that are issued could have an impact on national regulations or codes of practice.

Expert services

The Laboratory provides a range of technical services for which a charge is made. An important aspect of this function at present is the assessment of exposures from mobile phone base stations.

Aims of research

- To study exposures to UVR and NIR and compare them with exposure standards and current knowledge on biological effects.
- To examine the biological and biophysical basis of exposure limits.
- To develop experimental and theoretical methods for exposure assessment.
- To develop precise standards for the calibration of instruments used for exposure measurements.
- To provide well characterised exposure systems for biological research.
- To obtain quantitative and reliable data for the dissemination of public information.

Recent research

Development of EM field exposure measurement instruments

The research team has demonstrated the ability to design and build measurement equipment for assessing exposures. This is a valuable skill when appropriate equipment is not available commercially, as is often the case in a rapidly developing technology.

RF-dosimetry

Considerable technical expertise is going into the development of a technique for assessing the Specific Absorption Rate (SAR) from mobile phones. This is an important development as the SAR is a measure of the deposition of energy in the head (or body) of a phone user and is used to demonstrate compliance with exposure guidelines. With concern about possible effects of the use of mobile phones there are increasing calls for information on SAR to be made available to purchasers of mobile phones. The development of a standard testing protocol that can be used by phone companies and advisory bodies such as STUK to measure SAR will facilitate this. CENELEC is the body that has taken the lead internationally in the development of an internationally agreed method for measuring SAR; staff from STUK are closely involved in the work. Whilst it is expected that phone companies may carry out this test and provide information on SAR for individual phones, STUK could make an important contribution by publishing on its web site independently measured values of SAR on the phones currently on the market in Finland. Other methods of providing this information such as leaflets in phone shops could also be explored. As many of the phones marketed in Finland will also be on sale in other Nordic countries this work could be readily shared with other responsible bodies in these countries.

MRI Study

No information was provided on the MRI survey. This is a rapidly developing technology but little information has been published on any biological effects resulting from MRI examinations. A concern for the future, that may need to be considered in future work by the Group, is that there may be demands to increase the exposure of patients. The aim would be to obtain better quality images, but at higher exposure levels, at which there may be the potential for biological effects to become apparent. A watching brief on developments in MRI should be maintained

Broadband electric and magnetic fields

One aspect of this work has been the examination of exposures to pulsed broad band magnetic fields from store security gates. The assessment of exposure is complex and a novel assessment procedure has been developed that involves weighting the spectral components and comparing with ICNIRP guidelines. In some cases exposures can exceed public exposure guidelines although occupancy is generally short. In cases where a cash desk is situated near a gate, however, exposures can even exceed occupational exposure guidelines and consideration may need to be given to relocation of staff. This is an innovative approach to a potentially difficult situation and the results of the analysis have been published in Health Physics journal. It will be of considerable interest to see if this approach is generally accepted.

Security devices are widespread and are a source of public exposure to EMF's. Whilst mobile phones are at present the main cause of public concern there remains the possibility that other sources of exposure, such as security devices, could become an issue in the future. It is important that the NIR staff continue to identify novel sources and are ready to respond as and when questions of safety are raised by the media, by government, by the public or others.

Measurements have been made of exposures to RF radiation from about 15 base stations. The measurements have shown that in situations to which members of the public have access exposures are at most 0.5% of the ICNIRP exposure guidelines. The conclusion would be that such exposures do not present a health hazard. A report was issued about 5 years ago giving early measurements made in proximity to base stations. A further report summarising more recent measurements should be considered if there remains public concern about exposures. Prior approval may need to be obtained from any organisations for which the measurements were made under contract.

UV radiometry

Accurately monitoring solar and artificial sources of UVR is important, as this is a significant cause of skin cancer. The NIR Group has demonstrated that it has the necessary skills and competence to provide high quality measurements.

UVR exposure and risk studies

Exposure to UVR can increase the risk of skin cancer. In fair skinned people, as from Finland, the risk is greatest and the assessment of exposure from solar radiation and artificial sources is an appropriate research area. The main effort at STUK has been concerned with measuring exposure to solar radiation and sun-beds with little work on other artificial sources.

Safety of Mobile Phones

Dr Jokela has taken the lead in preparing a review of "Radiation Safety of Handheld Mobile Phones and Base Stations". This well prepared document was issued in January 1999. The report has provided the basis for advice to the public and media as well as for helping in the development of the research programme. It is a good example of a proactive approach to developing a response to public health issues.

Research plans for the next five years:

A number of areas of work that have been pursued over recent years are to be continued. In addition a number of new projects are being initiated and are given below. Comments are provided on those that are in a most advanced state and were considered in the review.

Development of exposure systems for animal and cell culture studies

There is close collaboration with work in Radiobiology and in the University of Kuopio on the development of exposure systems to examine possible effects of RF radiation. Many publications in the literature that have examined the effects of RF radiation have suffered from either poor physical dosimetry or poor experimental biology. It is important for the future that such studies bring together a high degree of competence in both these areas. The experimental work at STUK that is designed to examine the effects of RF radiation on both cells in culture and experimental animals brings together teams competent in both these areas and should produce a strong research effort. The collaboration between them seems to be effective and efforts have been made to ensure both sides understand the role of the other. The present development of an exposure system for rats for a programme of effects related work supported by the EU seems to be going well, although it is clear that design of the facility is proving difficult and the experimental study to be carried out at Kuopio will take some years. The Panel were told the exposure system should be ready in the middle of next year. This may prove to be optimistic, as it is important that comprehensive calibration is carried out before animal exposures commence.

Improving the accuracy of ultraviolet radiation measurements

A program of work is examining the UVR output of sun beds to ensure compliance with exposure guidelines. This is an important task as exposures of heavy users to artificial UVR in sun-beds can increase total exposures by up to 30%. The present system of measurement is time consuming with bulky equipment and this limits the number of measurements that can be carried out. A portable detector system based upon chip technology is to be investigated. If this proves to have sufficient resolution for spectral analysis of UVB and UVA then this will greatly facilitate future measurements.

To improve the information available on the use of sunbeds in Finland a survey of users is to be carried out. This will be of value in better targeting health information and giving guidance to users. It may also provide the basis for an epidemiological study (see comments on work in Epidemiology Group).

Solar UVR measurements, both broad band and spectral, are made routinely at STUK. These are provided to the Meteorological Office as an input to forecasting. There are also a number of other UVR monitoring sites in Finland run by the Meteorological Office. UVR monitoring is important for identifying any long term trends in exposure conditions as well as for showing changes in the ozone layer that occur mainly in the early Spring.

A number of other projects were not considered in any detail but are listed below. They would not appear to be in an advanced state of development:

- New antennas and measurement methods for 3rd generation cellular systems.
- The ASTE project: EMC & Safety Multimedia terminals.
- The combined effects of electromagnetic fields with environmental pollutants (CEMFC).
- Restricting exposure to broadband and pulsed electric and magnetic fields.

A number of other possible projects are listed under “Optional new research plans” on page 160 of STUK-A180. If many of these were to be taken forward, in addition to those in the present program, it is difficult to see how they could be properly supported. Management may need to set priorities that would depend upon the demands on STUK at the time.

General Conclusions

The Non-Ionising Radiation Laboratory has had an extensive program of work related to measurement of exposure to both UVR and EMFs with staff that demonstrate a high degree of skill and motivation.

With regard to UVR exposure the main emphasis of the work has been on measurement of solar radiation and on sun-beds. The measurement program has demonstrated that for most people sun-beds contribute less than 1% to total UVR exposure and so does not present a problem. For heavy users however, exposure can be increased by up to 30% and would significantly increase the risk of skin cancer. It is important that this information is made available, although the use of sun-beds remains an issue of personal choice. The continued measurement of solar radiation is important for monitoring any changes in the ozone layer as well as for giving advice on expected exposures.

For exposures to EMFs the main programme of work is now directed to measuring exposure to RF radiation from mobile phone technology. This has been the source of considerable public health concern and has needed to be carefully addressed. It has put considerable demands upon the staff involved and it has been important to prioritise the research work. Two topics of particular concern are the assessment of SAR from phones and exposures to RF radiation from base stations. Representative measurements of the present generation of macrocell base stations have demonstrated compliance with guidelines, with very low exposures of members of the public. As the technology develops there will be increasing numbers of base stations used to infill the network and support the increasing use of phones. These will be of lower power but will also be placed nearer to people. There will be a need to continue surveys of representative sites to provide assurance that guidelines are complied with. With regard to SAR from phones it is important that the international development of a standard testing procedure by CENELEC continues to be followed and ideally an agreed SAR test standard implemented at STUK. Presently there are no collaborative projects in this area with other Nordic countries. This is an area that would lend itself to collaboration.

Funding is a key feature of the work. There is the potential for funding from mobile phone companies but it is important that any work carried out in this area by STUK is independent and seen to be so. Whilst this does not exclude funding from companies in the telecommunications business it must be separated from the work by a “firewall” and not make up too large a proportion of the funding requirement.

Publications

During the last five years, the Non-ionising Radiation Laboratory has published altogether 19 peer reviewed articles in international journals, several proceeding papers and 15 reports.

Recommendations

A number of recommendations are made related to the work of the Laboratory. These are:

- Continued monitoring of solar radiation to improve the baseline of information and to support solar UVR forecasting.

- Further assessment of exposure to UVR from sunbeds: This will be facilitated by developing the use of more portable monitoring equipment.
- Improving the provision of information on possible health effects of UVR to the public.
- Development of methods for the testing of SAR from mobile phones. Implementation of an international test standard if it is considered acceptable for use in Finland.
- Provision of independent information on SAR from phones.
- Actively consider sharing the measurement of SAR from present and future phones with bodies in other Nordic countries. Other potential synergies that could be achieved by co-ordination should be explored.
- Further monitoring of exposures to RF radiation from base stations to demonstrate compliance with guidelines and to give public reassurance.
- Ensure that advice from STUK is seen to be independent.
- The number of activities supported by the laboratory should be monitored by management to ensure that priorities for STUK can be met.

At present there seems to be no good reason for separating regulatory and research responsibilities.

Annex A: Objectives and method of evaluation

The evaluation of STUK was to address the following main issues:

1) Appropriateness of STUK's research activities in relation to relevant issues in nuclear sciences: Are STUK's radiation, environment and health related research activities on relevant areas of interest? Has STUK been successful in implementing new strategies and techniques in radiation protection with the help of its research and development activities?
2) Social relevance and effectiveness of the activities: Have STUK's research and development activities played an important role in disseminating the needed information to the general public and politicians on issues related to radiation, environment and health?
3) Steering by information: Assessment of STUK's information steering and its impact.
4) Prioritizing STUK's various activities: Are STUK's research and development activities balanced and are the priorities set in a proper manner?
5) Quality of STUK's research activities: Are STUK's research activities of high international quality and is the continuity of high quality research guaranteed? Is STUK's research collaboration nationally and internationally properly and efficiently organized?
6) The relation between costs and results: Are STUK's research activities organized in a cost-efficient way?

Further more it was to be evaluated whether the proper and high quality basic research education was guaranteed for those young natural scientists who wish to choose radiation, environment and health as their career and how STUK is ensuring that qualified researchers can be recruited also in the future?

The disciplines that were to be evaluated were:

1) radiation biology and epidemiology

2) radioecolocy

3) development of tools for emergency preparedness and management

4) natural radiation

5) medical radiation

6) non-ionising radiation.

For the evaluation the following documents were prepared:

- Report STUK-A180: Research activities of STUK 1995-1999; the report summarises STUK's own research activities related to radiation protection in 1995-1999
- Report STUK-A179: Research projects of STUK 2000-2002; the report summarises STUK's own research projects on radiation protection in 2000-2001
- CV's of the Research Professors, Heads of Laboratories, Senior Scientists, Scientists and Project Leaders involved in research were updated

- Strategic plan of Research and Environmental Surveillance Department for years 1999-2001 was translated into English
- A guide of STUK Quality Manual, STUK 3.2: Research, was translated into English
- A list of STUK's research contracts, scientific co-operation and training activities over the last five years was compiled.

A selection of most important publications by the different laboratories during the last five years was also sent to the members of the Evaluation Panel.

Based on the material provided by STUK the Evaluation Panel members prepared questions to be used in discussions with the different laboratories during the visit to STUK.

The visit to STUK was arranged October 23-25. Program of the visit included introductory part in which general objectives of the review were gone over and overview of STUK was presented. In the end of the visit there was an exit meeting in which the team presented their first impressions based on the evaluation. Most of the time was devoted to discussions with the representatives of different laboratories. Laboratories were represented by one or more experts. The units and laboratories dealt with were:

1) Surveillance, Management Unit

2) Natural Radiation

3) Radiation Hygiene

4) NPP Environment

5) Ecology and Food Chains

6) Airborne Radioactivity

7) Regional Laboratory in Northern Finland

8) Medical Radiation

9) Radiation Biology

10) Radiation Metrology

11) Non-ionising Radiation

Annex B: Terms of reference of the Evaluation Panel

STUK will provide evaluators material concerning history, status and strategy of STUK's research activities.

The evaluators shall make a visit to STUK to interview the management and personnel of the different laboratories of STUK. The site visit to STUK will take place in September - October 2000 and it will last up to four days.

After having studied the material and conducted the interviews during the site visit the evaluators are expected to draw up a final evaluation report. The final evaluation report shall be completed in December 2000 and submitted to the Ministry of Social Affairs and Health.

The workload of the head of Evaluation Panel will be about sixteen working days, during the period between August 2000 and December 2000.

The work will be carried out by the Evaluation Panel on the basis of evaluation material provided by STUK and the information gathered during the site visit.

All information, data and knowledge of any kind regarding STUK whether gathered in oral or written form by the evaluators during the evaluation process shall be considered confidential during a period of five years from the delivery of the final report and shall not be disclosed by the evaluators to any third party. Only publicly available material is to be considered non-confidential. All the material to be considered confidential shall be returned to the Ministry of Social Affairs and Health.